DOT/FAA/CT-94/62

FAA Technical Center
Atlantic City International Airport,
N.J. 08405

Prototype Stop Bar System Evaluation at Seattle-Tacoma International Airport

Eric Katz

November 1994

Final Report

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

U.S. Department of Transportation
Federal Aviation Administration

NOTICE

Technical Report Documentation Page

1. Report No. DOT/FAA/CT-94/62	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PROTOTYPE STOP BAR SYSTEM EVALUATION AT SEATTLE-TACOMA INTERNATIONAL AIRPORT		5. Report Date November 1994
		6. Performing Organization Code ACD-110
7. Author(s) Eric S. Katz		8. Performing Organization Report No.
9. Performing Organization Name and Address Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405		13. Type of Report and Period Covered Final Report
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

An interim United States stop bar specification was developed by the Federal Aviaition Administration Technical Center. Using the guidance material contained in the interim specification, a full-scale prototype stop bar system was installed to protect runway 16R/34L at the Seattle-Tacoma International Airport (SEA). The system consists of two stop bars which incorporate both inset and elevated red light fixtures. Associated with each stop bar are green inset lead-on lights and microwave detectors that provide for automatic switching of the stop bar/lead-on light segments. Once installed, the SEA stop bar system was operated during air traffic controller training sessions and under actual low-visibility weather conditions for evaluation and user organization familiarization. Air traffic controller and air-carrier pilot questionnaires were distributed and returned to the FAA Technical Center for analysis after completion. The questionnaires were designed to solicit information regarding the effectiveness and reliability of the stop bar system. As a result of the evaluation, the U.S. stop bar lighting configuration, as developed and described in the interim specification, was found to be satisfactory and acceptable to user pilots.

17. Key Words Stop Bar Lighting System Current-Carrier Control System		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161	
19. Security Classif. (of this report) UNCLASSIFIED	20. Security Classif. (of this page) UNCLASSIFIED	21. No. of Pages 81	22. Price

Form DOT F 1700.7 (8-72)

TABLE OF CONTENTS

APPENDIX

A -- Draft FAA Stop Bar Specifications

B -- Stop Bar Control System Manufacturer's Descriptive Material

C -- Summary of User Pilot Questionnaire Comments

D -- Summary of Air Traffic Controller Questionnaire Comments

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (CONTINUED)

EXECUTIVE SUMMARY

The purpose of this project was to develop written guidance material that would facilitate the implementation of a stop bar system within the National Airspace System (NAS). An interim stop bar specification was developed by the Federal Aviation Administration (FAA) through a cooperative effort involving contributions from representatives of the Flight Standards Service, the Office of Airport Safety and Standards, the Air Traffic Rules and Procedures Service, and the FAA Technical Center. The draft specification detailed both configurational and operational specifications for the stop bar system.

Using the guidance material contained in the draft specification, a full-scale prototype stop bar system was installed to protect runway 16R/34L at the Seattle-Tacoma International Airport (SEA).

Once installed, the SEA stop bar system was operated under simulated and actual low visibility (Category II/III) weather conditions for evaluation and user organization familiarization. Air traffic controller and user air-carrier pilot questionnaires were distributed and returned to the FAA Technical Center for analysis after completion. Special training sessions for air traffic controllers and SEA maintenance personnel were held to insure that all were familiar with system operation and maintenance requirements.

As a result of the evaluation, the U.S. stop bar system, as developed and described in the draft specification, was found to be satisfactory and acceptable to user pilots.

The prototype stop bar system was operated for approximately one year. At the conclusion of the evaluation, the system at SEA was retained in service as a necessary component of the airport Surface Movement Guidance and Control System.

INTRODUCTION

BACKGROUND.

In recent years, the advent of sophisticated electronic guidance devices have significantly enhanced the pilot's capability to operate aircraft under extremely reduced visibility conditions. In fact, landing and takeoff operations are now conducted under conditions approaching virtually zero visibility. As a result, the most demanding of tasks facing a pilot may well be that of taxiing the aircraft from the runway to the terminal or vice versa. This situation is just that which makes the possibility of runway incursions and potential ground collisions an increasingly fearful prospect.

Although airside ground vehicular and aircraft traffic continues to operate under low-visibility weather conditions that make air traffic controller visual observation all but impossible, certain non-visual means of monitoring surface movements have come into widespread use. Airport Surface Detection Equipment (ASDE), a form of ground radar, materially assists controllers in monitoring traffic during low-visibility conditions. In spite of this, a more positive method for isolating and identifying active runway areas is necessary, and the stop bar concept has been developed to fulfill this requirement.

While stop bars have been in use at the London Heathrow Airport for at least thirty years as part of the segmented taxiway lighting system for guiding aircraft between the runways and gates, it has been only a few years since the first stop bar systems appeared at other European airports. The first "Official" published material concerning the configuration for, and use of, stop bars appeared in the International Civil Aviation Organization (ICAO) Volume I Annex 14, Aerodrome Manual of International Standards and Recommended Practices. Pertinent sections are:

> 5.3.18.1 A stop bar shall be provided at each taxi-holding position associated with a runway intended for use in runway visual range conditions less than a value of the order of 400 m.
>
> 5.3.18.5 Stop bars shall be located across the taxiway at the point where it is desired that traffic stop.
>
> 5.3.18.7 Stop bars installed at a taxi-holding position shall be unidirectional and shall show red in the direction of approach to the runway.
>
> Note. The provision of stop bars <u>requires</u> their control by air traffic services.

An amendment to the basic ICAO manual Stop Bar section, adding additional green in-pavement "lead-on" lights between the bar and the runway centerline, has been proposed and will probably be adopted shortly.

The stop bar system has recently been formally adopted by the Federal Aviation Administration (FAA) and required for use at airports conducting takeoff and landing operations under low-visibility conditions of less than 600-foot runway visual range (RVR). FAA order No. 6750.24B, Instrument Landing System (ILS) and Ancillary Electronic Component Configuration and Performance Requirements, contains the following requirement for stop bars as a component of the taxiway centerline lighting system:

> 7.i <u>Taxiway Centerline Lights</u>. For operations below RVR 600, at least one continuation of taxiway centerline lighting extending from the runway to the ramp/apron area is required. All taxiways which are illuminated during these operations <u>must be provided with red stop bar lights</u>, controlled by the air traffic control tower, when the illuminated taxiway leads into any runway being used in operations below RVR 600.

In addition, Advisory Circular 120-57, Surface Movement Guidance and Control System states that for operations below 600-foot runway visual range (RVR) all illuminated taxiways that provide access to an active runway (regardless of whether they are part of the taxi route) should have stop bars installed.

While the above indicated FAA documents state the requirement for stop bar usage, this evaluation will lead to installation specifications and system performance criteria.

<u>PURPOSE</u>.

The problem of runway incursions, the unintentional intrusion by a taxiing aircraft or ground vehicle onto an active runway, has been the subject of considerable investigative effort during the past decade. The occurrence of fatal ground collisions at air carrier airports has provided impetus to efforts to develop visual aids for avoiding such incidents. One of the most promising concepts proposed has been to surround the active runway with a "ring of red", meaning the provision of red warning lights at all entrances to a runway whenever aircraft are landing or taking off. These lights, where provided, have come to be known universally as "Stop Bars", and are intended to convey a "no access" message to pilots encountering them.

In order to retain their effectiveness, stop bars must be "controlled", and extinguished whenever the pilot is to be allowed access onto or across the runway.

International Civil Aviation Organization (ICAO) Annex 2, Rules of the Air, states that a pilot should never cross an illuminated stop bar since, should he be cleared to do so even once, he might consider doing so again as a result of misinterpreted verbal air traffic control (ATC) commands. The requirement for control of stop bars introduces significant complication into the design and installation of such systems.

The purpose of the developmental/evaluational project described herein was to gain practical design, installation, and operational expertise and experience with a stop bar system which is in general compliance with ICAO proposed standards.

OBJECTIVE.

The object of this project was fourfold:

1. To develop a stop bar specification that would facilitate the implementation of a stop bar system within the National Airspace System (NAS).

2. To design, procure, and install a prototype stop bar system at a suitable major air-carrier airport for testing and demonstration purposes.

3. To evaluate the suitability and effectiveness of the prototype system using input from:
   a) user pilots
   b) air traffic controllers

4. To evaluate a current-carrier type of system for controlling stop bars.

PROTOTYPE SYSTEM DEVELOPMENT

LIGHTING CONFIGURATION DEVELOPMENT.

Since stop bar installations at international airports within the United States should be configured to meet the published ICAO requirements, as detailed in Annex 14 of the Aerodrome Manual, a decision was made to conform to the established criteria in so-far as possible. Therefore the ICAO system characteristics such as inset light fixture spacing, color, minimum intensity, and location were selected as the standard for U.S. usage. Although not yet officially adopted by ICAO, the inclusion of the proposed green in-pavement "lead-on" light segment was also decided upon. A simplified depiction of the basic U.S. stop bar configuration is provided as figure 1.

This configuration complies with ICAO standards in all respects, with the following two exceptions:

1. The U.S. stop bar configuration does not meet the following proposed ICAO requirement:

> 5.3.18.8A Selectively switchable stop bars shall be installed in conjunction with at least three taxiway centerline lights (extending for a distance of at least 90 m from the stop bar) in the direction that it is intended for an aircraft to proceed from the stop bar.

The location of holding positions at runway entrances, at which point the stop bars will be collocated, is often so near the runway as to preclude the installation of a 90 m minimum length of "lead-on" taxiway centerline lights. In addition, rather than stipulating a minimum number of taxiway centerline "lead-on" lights, the U.S. stop bar configuration will include "lead-on" lights that are spaced as shown in A/C 150/5340-19.

2. Although the U.S. stop bar configuration includes elevated stop bar lights, these lights are located 6.5 feet from the edge of the full strength taxiway pavement, as opposed to the ICAO recommended distance of not less than 3 meters. A pair of elevated lights are included in the stop bar configuration because of the possibility of the inset stop bar lights being obscured from the pilots view by snow, ice, or cockpit cutoff angle.

The ICAO Annex 14 Stop Bar section does not speak to, or specify, details of stop bar system operation, other than requiring that they be "controlled" or "switchable". Also, ICAO does not provide guidance concerning methods of control, equipment (panels) for ATC usage, requirements for monitoring system integrity, etc.

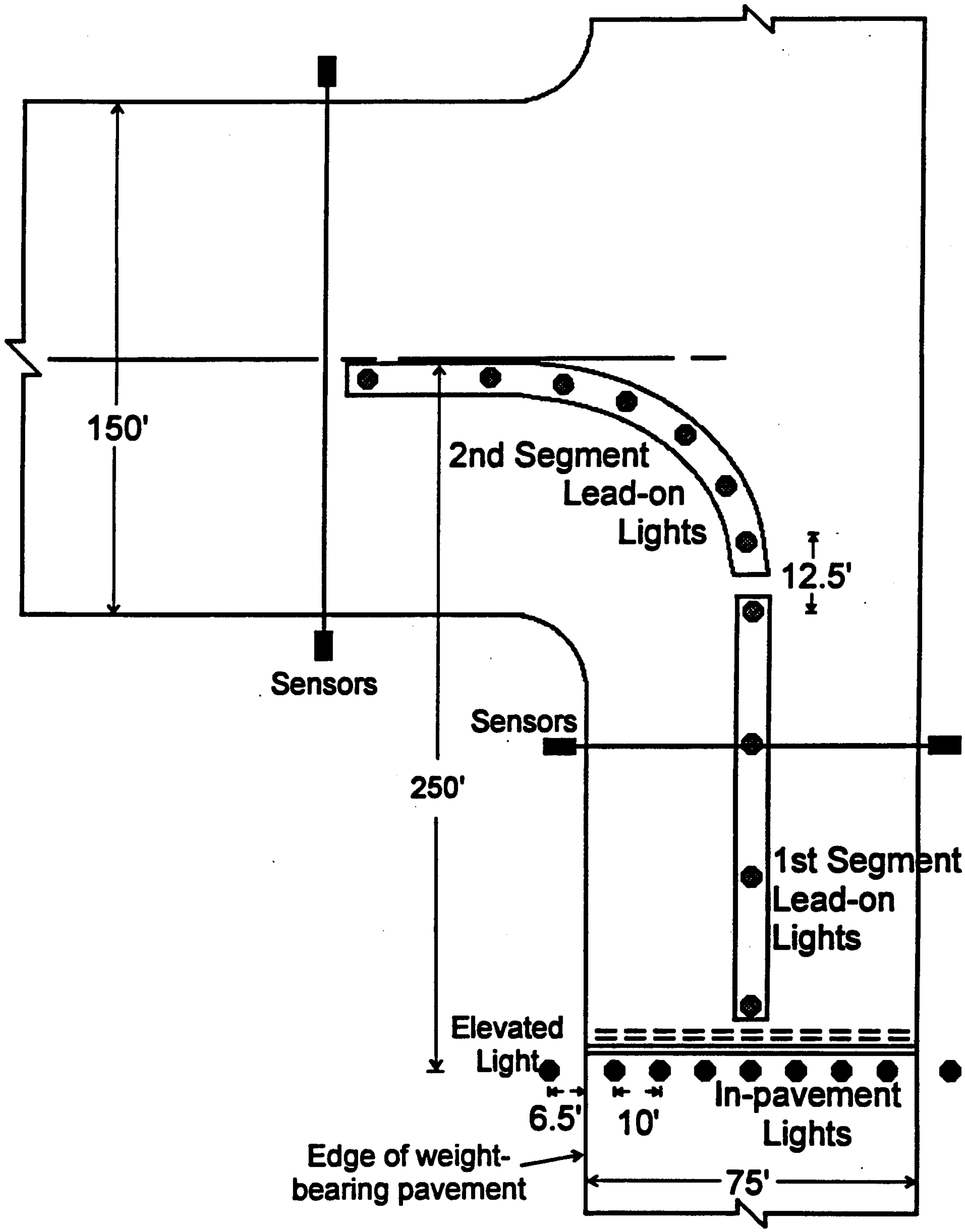


FIGURE 1. BASIC U.S. STOP BAR CONFIGURATION

These installation and operational details must be provided to system designers so that future U.S. stop bar installations will be uniform in operation and standardized from the user (pilot and controller) viewpoint.

DOCUMENTATION DEVELOPMENT.

A decision to develop, at the least, a draft FAA stop bar specification detailing both configuration and operational specifications was made for the following reasons:

1. Guidelines would be required to facilitate design and installation of a prototype stop bar system for subsequent evaluation.

2. Concurrently with installation of the prototype system for testing, other airport authorities would be initiating projects for future stop bar installations at a number of other airports. The draft specification would provide the necessary basic configurational information needed for preliminary design proposals.

3. The draft specification would serve as a basis for further detailed documentation that would surely be required once the prototype evaluation had been successfully completed and the final stop bar system definitized.

The necessary draft stop bar specification was developed by the FAA through a cooperative effort involving contributions from representatives of the Flight Standards Service, the Office of Airport Safety and Standards, the Air Traffic Rules and Procedures Service, and the FAA Technical Center. This specification provides interim guidance relative to the following stop bar system characteristics:

1. Configuration, to include details of function, location, spacing, color, etc.

2. Field Installation Design, to include theory of operation and control (command & monitor) techniques.

3. Remote (ATC Tower) Control Panel Design, to include standardized configurations and alert/alarm displays.

4. Monitoring Requirements.

A reproduction of the draft specification, as used for guidance in the design, procurement, and installation of the prototype stop bar system is provided as appendix "A" to this report.

PROTOTYPE SYSTEM INSTALLATION

EVALUATION SITE SELECTION.

The FAA has designated four major air-carrier airport locations as "Demonstration Airports", to serve as sites for show-casing the latest state-of-the-art advances in airport equipment and systems. The designated airports are:

1. Boston Logan International Airport

2. New Denver International Airport

3. Greater Pittsburgh International Airport

4. Seattle-Tacoma International Airport

The Seattle-Tacoma (SEA) Airport was selected, after careful consideration of all four sites, as the most suitable for evaluation of the prototype stop bar system for the following reasons:

1. The runway configuration was relatively simple, since at the time of the testing only one of the two parallel runways was configured for use in Category III low visibility weather conditions. Therefore, the installation would involve only two stop bar locations to serve the two Category III runway entrance/exit routes.

2. Air carriers serving this airport were using aircraft certified for, and air crews trained and certified for, Category III operations.

3. The airport operating authority, the Port of Seattle, had indicated a willingness to support the evaluation effort with administrative and maintenance personnel.

4. The local FAA ATC organization had indicated a willingness to cooperate in operating and evaluating the prototype system.

5. Airport based air carriers, and especially Alaska and United Airlines, had indicated a willingness to cooperate in obtaining user pilot opinion as to the effectiveness of the system under actual low-visibility conditions.

The SEA airport physical layout of runways and taxiways is depicted in figure 2.

SEATTLE–TACOMA INTERNATIONAL AIRPORT

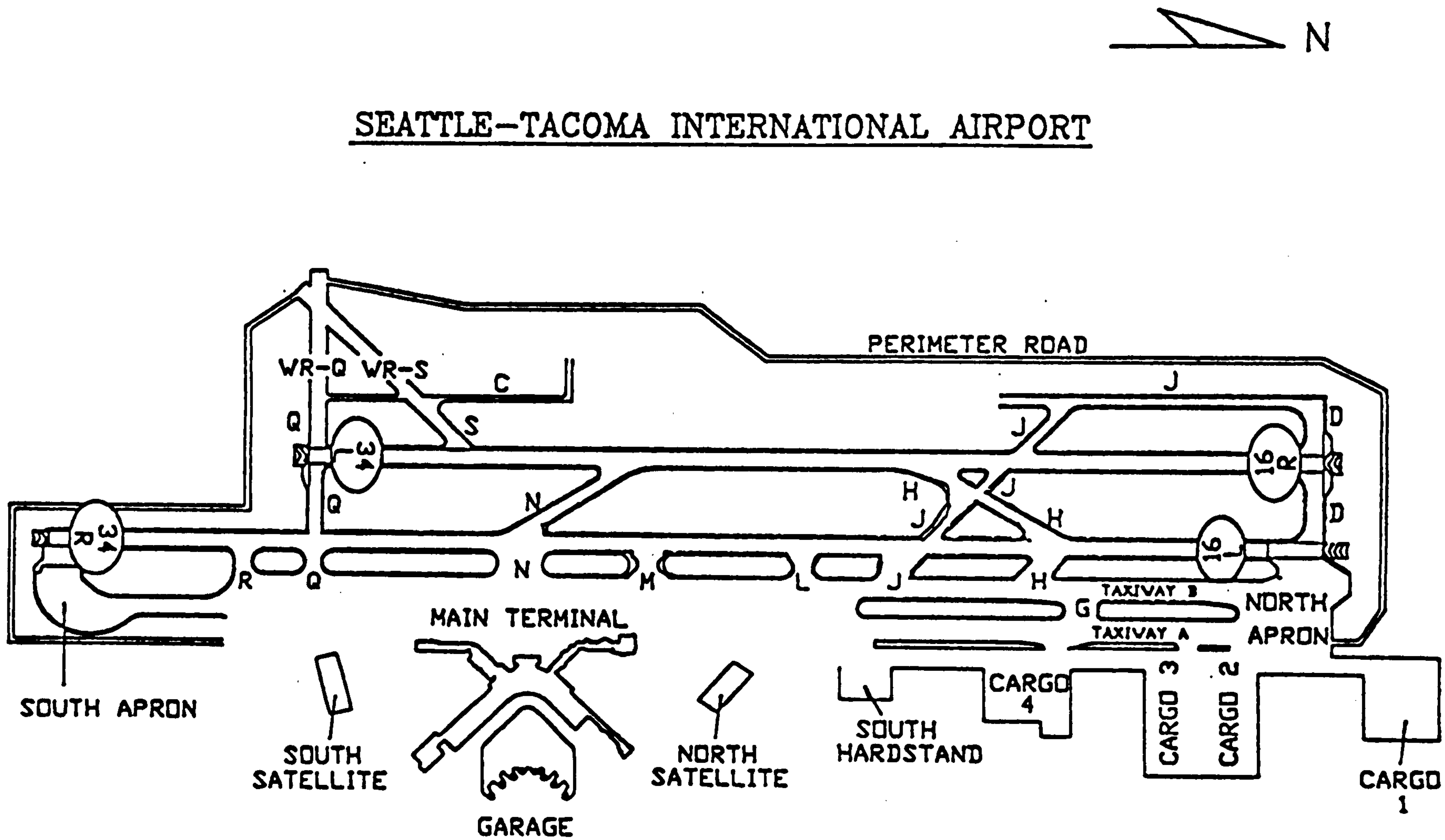


FIGURE 2. SEA AIRPORT DIAGRAM

SYSTEM DESIGN AND INSTALLATION.

With regard to system design, the most difficult problem was that of selecting the most appropriate technique for attaining ATC tower remote control of the stop bar field lighting displays. Use of conventional hardwire, or even fiber-optic, control systems at existing airports invariably involves considerable installation cost in routing cables under wide and multiple expanses of concrete to reach the usually remote taxiway/runway intersections. Therefore two alternative control techniques were considered: radio remote control and radio-frequency signals superimposed upon the existing taxiway power cables (current-carrier control).

After careful consideration, the radio remote control alternative was rejected for the following reasons:

1. Previous experience with this type of control, gained during evaluation of an earlier stop bar system at J.F.Kennedy International Airport in New York, revealed that considerable interference from other radio devices commonly utilized at large airports must be anticipated. This can lead to frequent system malfunction alarms and subsequent disruption of stop bar system operation.

2. Radio remote control systems that include an individual lamp monitoring capability, as required in the prototype stop bar application, may not provide the necessary very short (less than 2 seconds) response to system status change commands. This is especially true when more than one or two stop bar locations must be controlled in sequence.

Current-carrier control was selected for the SEA application for the following reasons:

1. Retrofitting of this system at SEA would involve the minimum installation cost and require virtually no interruption of airport operations.

2. Use of this control technique at domestic airports has been virtually nil, and application of such a state-of-the-art concept at SEA would provide an ideal opportunity for evaluation and demonstration of this critical subsystem.

3. Vendors of the current-carrier control system were most anxious to introduce the product into the airport market and could be depended upon to provide significant design, installation, and maintenance support.

Prior to selection of a vendor, FAA Technical Center engineers thoroughly investigated the technical capabilities, production facilities, and supporting services resources of each of the two control system vendors (AT and ADB) identified as potential sources for the required equipment.

Demonstrations of system operation were witnessed, wherein actual production components were connected to typical airfield series lighting circuits to remotely control standard stop bar system devices. As a result, a determination was made that both systems could provide the necessary control/monitoring function and that neither was technologically superior to the other.

Subsequently, system price quotations were obtained from each of the manufacturers and, as a result of the cost proposals, ADB was selected to provide the control equipment and technical support for the installation at SEA airport.

The ADB control system, depicted diagrammatically in figure 3, consists of the following basic components:

Control Panels - Located in the air traffic control tower, these 2 identical mimic panels provide push button control for the individually switchable stop bars serving taxiways D and Q. The panels also contain light emitting diode (LED) indicator lights to monitor system status and visual and aural alarm devices (figure 4).

Low-Visibility Switch Panel - This selector switch panel, also located in the ATC tower, provides for activation of the stop bar system (figure 5).

Tower Computer - This computer, located in the equipment room beneath the ATC tower cab, processes commands (Clearance, Cancel, and operational mode changes) from the control panels for transmittal to the vault computer via a 2-pair hardwire modem connection. Conversely, it also processes information from the vault computer to the control panels to indicate system status and alarms in the event of component failures.

Vault Computer - This computer, located in the terminal basement field lighting vault, comprises the "heart" of the operating system. It contains the system program and dictates operation of the entire control and monitor system. It receives commands from the tower computer and executes them by communicating with the individual "Master" control units associated with each of the two separate taxiway stop bar circuits. It also receives system status information from the "Master" units for processing and transmittal to the tower computer.

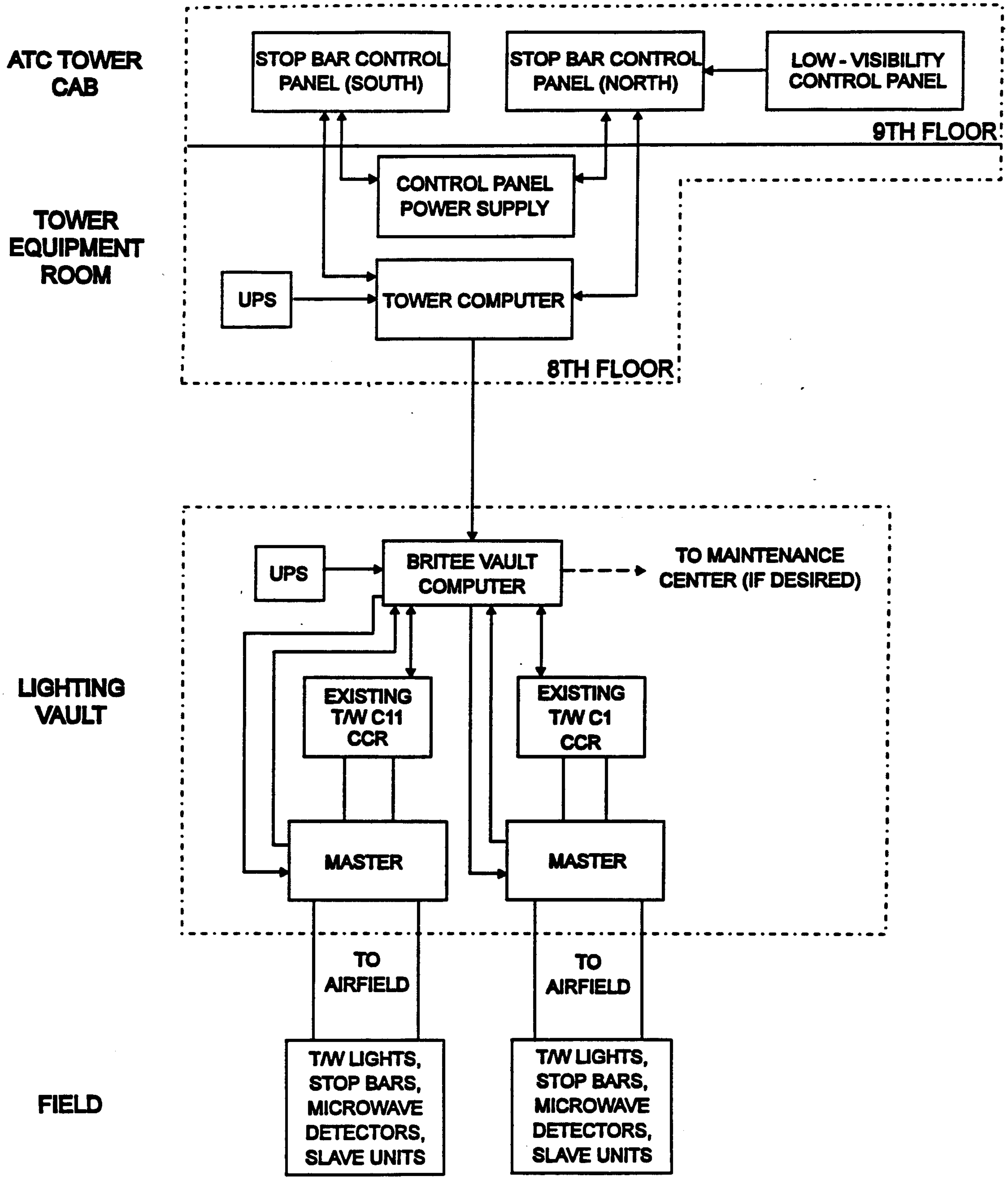


FIGURE 3. ADB CONTROL SYSTEM BLOCK DIAGRAM

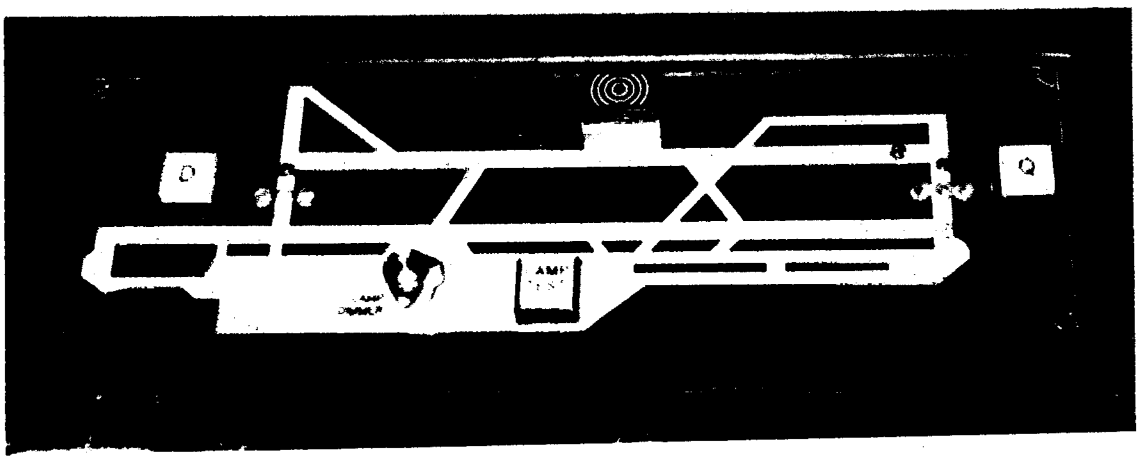


FIGURE 4. STOP BAR MIMIC PANEL

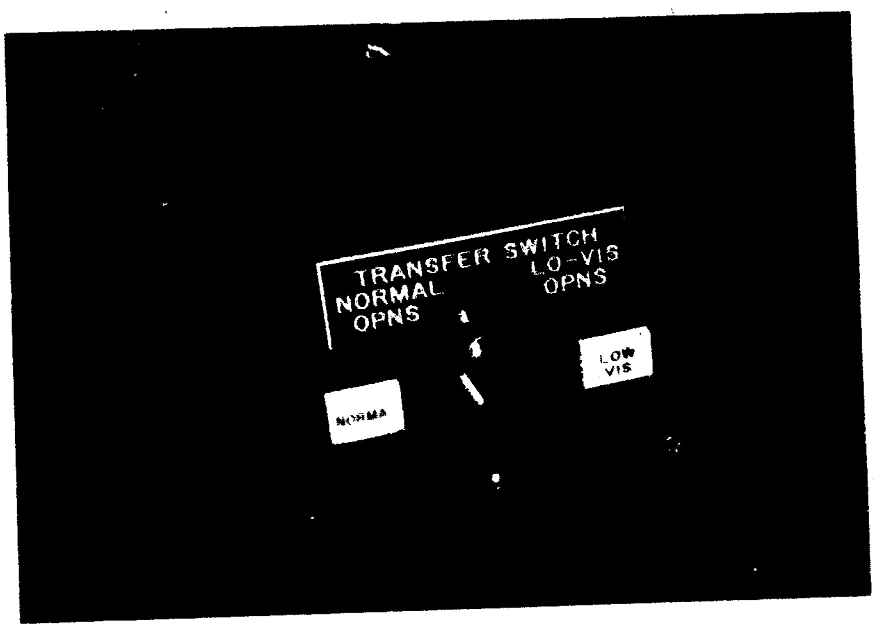


FIGURE 5. LOW-VISIBILITY SWITCH PANEL

Uninterruptable Power Supply (UPS) - Both the tower computer and the vault computer are provided with 700 volt-ampere (VA) UPS power supplies that, in the event of a main airport power failure, will continue to supply power to these computers for a minimum of 15 minutes. Airport emergency generating equipment can be expected to restore normal power to the control system equipment within a minute or two of a commercial power interruption.

Master Units - These two control units, also located in the lighting vault adjacent to Constant Current Regulators D and Q, (previously C-1 and C-11) provide control of all switchable devices (stop bar lights, lead-on lights, and microwave detectors) connected to their individual field lighting circuits by slave units. Communication is achieved through radio-frequency signals superimposed upon the existing lighting power cables. The master units also process device status information received from the slave units in the field for transmission to the vault computer.

Slave Units - These are individually addressable switching and monitoring components located at each controlled field device (lights and detectors). On command from the master units, they turn individual lights on or off as required to display the desired stop bar system configuration. They also monitor the status of their designated device and communicate its status continuously to the Master unit.

Maintenance Computer - This computer, also located in the terminal basement lighting vault, processes system status information from the main vault computer and displays it on a monitor screen for use by airport maintenance technicians. The information can be used for fault detection, lamp outage data collection, and other maintenance purposes.

With regard to the stop bar field lighting and control equipment installed at SEA Airport, the following details are provided for taxiways D and Q.

Taxiway D:

Elevated Stop Bar Lights - One at each side of the taxiway holding position (total of 2) with the associated slave units for on/off control and monitoring.

In-pavement Stop Bar Lights - Eleven L-850BS dual light (red/yellow) unidirectional 80-watt fixtures with the associated slave units for yellow/red/off control and monitoring. This portion of the lighting array also serves as a yellow hold bar whenever the stop bar function is disabled.

In-pavement Lead-on Lights - Fifteen L-852 bi-directional 45-watt light (green) fixtures with the associated slave units for on/off control and monitoring. Seven of these lights (first segment) are switched in unison with the red stop bar lights. The remaining eight (second segment) are switched independently after aircraft passage.

Microwave Detectors - Two pair of elevated microwave detectors are used. One pair is located across the taxiway near the runway edge and the other pair is located across the runway near the last lead-on light location. Slave unit pairs (receiver/transmitter) provide sensing feedback for system light switching.

By-pass Units - All other lights in the circuit that do not require switching are equipped with isolation transformer by-pass units to facilitate efficient transmittal of the control signals.

Taxiway Q:

Elevated Stop Bar Lights - One at each side of the taxiway holding position (total of 2) with the associated slave units for on/off control and monitoring.

In-pavement Stop Bar Lights - Eight L-850BS dual light (red/yellow) unidirectional 80-watt fixtures with the associated slave units for yellow/red/off control and monitoring. This portion of the lighting array also serves as a yellow hold bar whenever the stop bar function is disabled.

In-pavement Lead-on Lights - Four L-852 bi-directional 45-watt light (green) fixtures with the associated slave units for on/off control and monitoring. These lights are switched in unison with the red stop bar lights.

Microwave Detectors - One pair of elevated microwave detectors is located across the taxiway near the runway edge. A slave unit pair (receiver/transmitter) provides sensing feedback for system light switching.

By-pass Units - All other lights in the circuit that do not require switching are equipped with isolation transformer by-pass units to facilitate efficient transmittal of the control signals.

Manufacturer's current-carrier control system descriptive brochures and data sheets are provided as appendix B to this report.

Installation of the complete two location stop bar system at SEA commenced on September 8, 1992 and was completed in time to permit Category III operations on December 10, 1992.

STOP BAR OPERATIONAL CONCEPT

GENERAL

FAA policy at the time this report was written required stop bars to support landing and takeoff operations conducted in low-visibility conditions of less than 600-foot RVR. However, at those airports conducting such operations with stop bar installations, the stop bars are used whenever any operations are conducted in low-visibility conditions of less than 1200-foot RVR. Therefore, at any airport having stop bars installed and operational, they will be used by ATC for all operations below 1200-foot RVR.

INDIVIDUAL STOP BAR OPERATION

In general, the SEA stop bar operational sequence is as follows:

1. For all operations in visibility conditions at or above 1200-foot RVR, the stop bar system will be deactivated and the normal mode yellow holding position lights and green lead-on lights will be illuminated. The yellow holding position lights are not part of the stop bar system. SEA airport authorities decided to install dual aperture lighting fixtures that display red stop bar lights through one aperture and yellow holding position lights through the other. This configuration for the two SEA stop bar locations is depicted in figures 6 and 7.

2. For operations in low-visibility conditions of less than 1200-foot RVR, pilots of aircraft awaiting takeoff or position and hold clearances will be presented with a stop bar signal consisting of a line of red lights across the taxiway at the holding position. All green centerline lights (lead-on lights) between the stop bar and the runway will be extinguished (the so-called "Black Hole").

3. Once the air traffic controller issues the appropriate <u>verbal</u> clearance, he will activate the stop bar clearance push button, causing the red lights of the stop bar to be extinguished and all of the green centerline lights beyond the stop bar to be illuminated.

4. Shortly after the cleared aircraft passes the stop bar location a sensor (microwave detector at SEA) will detect aircraft passage and re-illuminate the red stop bar lights to prevent following aircraft from entering the runway confines. At the same time the first segment of green lead-on lights will be extinguished, so as to reestablish a "black hole" behind the red light array. The second segment of green lead-on lights, if provided, will remain illuminated to provide visual guidance for the aircraft cleared onto the runway.

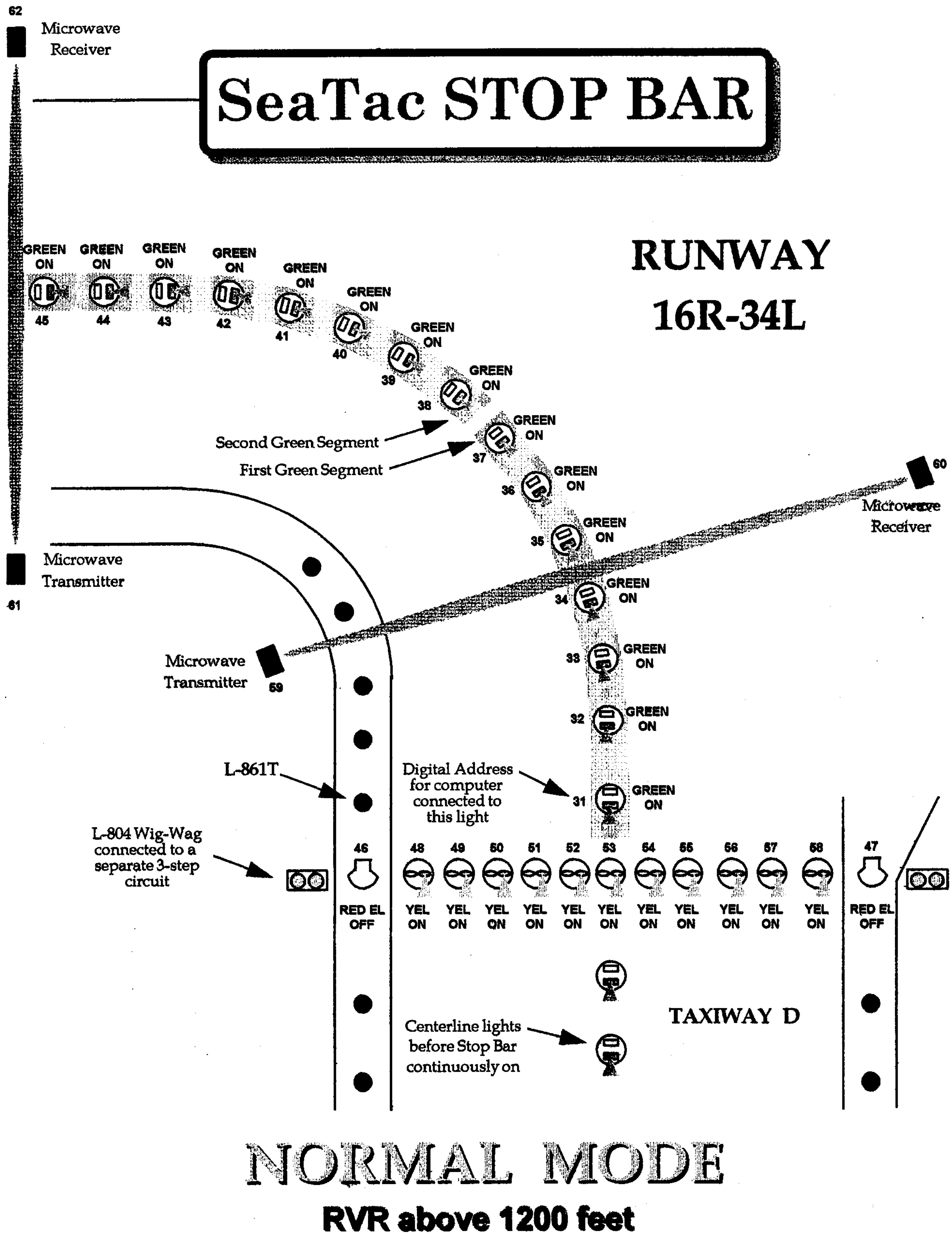


FIGURE 6. TAXIWAY D NORMAL MODE CONFIGURATION

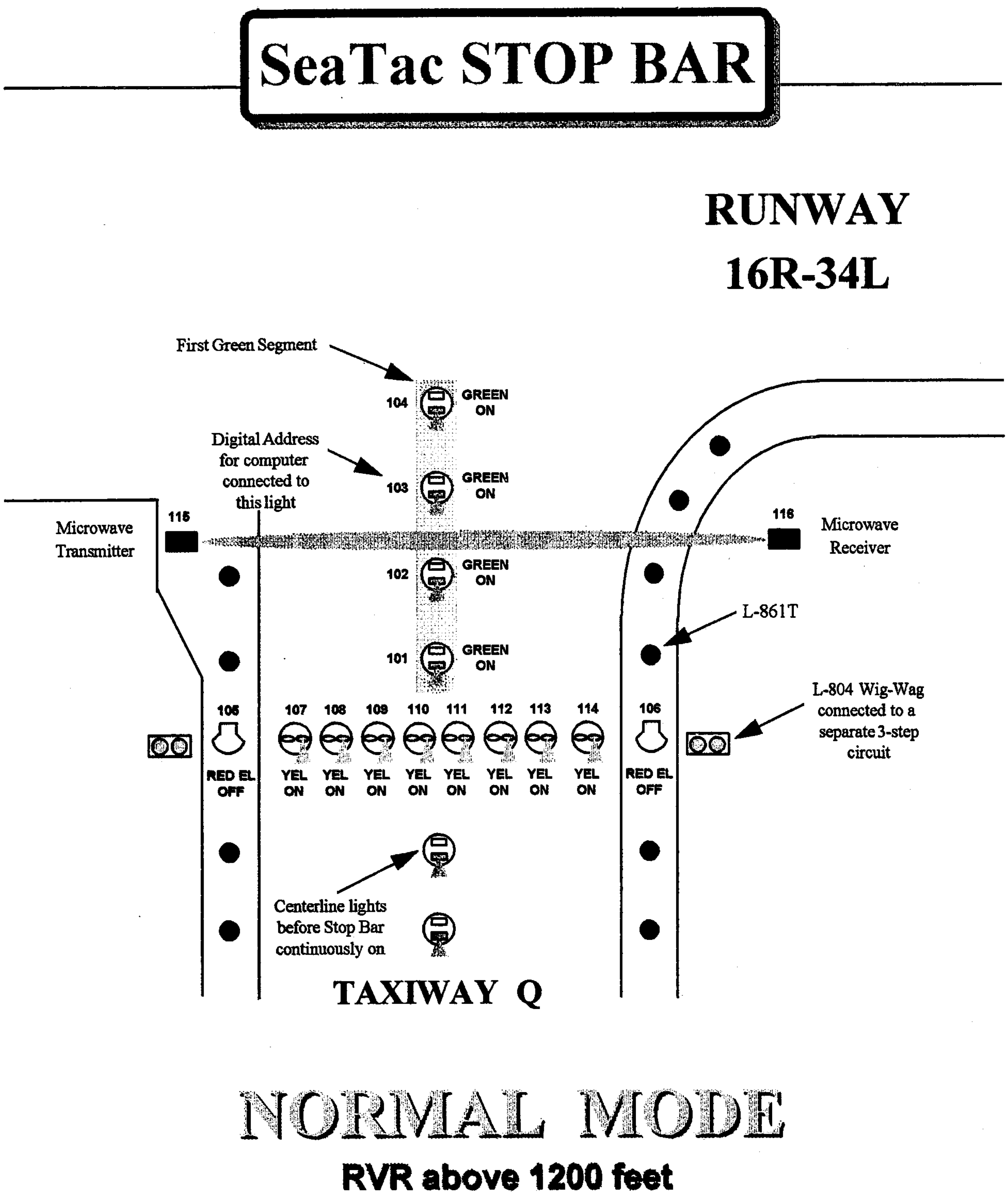


FIGURE 7. TAXIWAY Q NORMAL MODE CONFIGURATION

5. Once the cleared aircraft turns onto the runway centerline, while lining up for takeoff, a second sensor will detect the aircraft's arrival on centerline and extinguish the second segment of green lead-on lights. This action restores the entire Stop Bar array to the original "Hold" configuration.

(At some locations only a single sensor and a single segment of green lead-on lights are provided. In this case the movement of the cleared aircraft past the first, and only, sensor will restore the entire stop bar array to the original hold configuration.)

At SEA airport, the stop bar installation protecting the taxiway D runway entrance is of the 2-segment green lead-on lighting configuration. The installation protecting the taxiway Q runway entrance is of the simpler 1-segment green lead-on lighting configuration. A depiction of the sequential operation of these two stop bar installations is provided in figures 8 through 14.

In the unlikely event of a total control system failure, some form of fail-safe mode of operation must be provided. Since the stop bar concept is based upon the premise that pilots will never be permitted to cross an illuminated stop bar signal (red lights), a failure mode is incorporated into the system software program. If communication with the field lighting components is lost due to computer failure or interface wiring faults, the slave units in the field will immediately revert to the fail-safe mode of operation as follows:

1. All red in-pavement and elevated lights of the affected stop bar installation will be extinguished.

2. The first segment of lead-on lights will be extinguished, while the second segment, if provided, will remain illuminated.

3. The yellow in-pavement holding position lights (if installed) will be illuminated.

4. An alarm signal is immediately provided in the air traffic control tower to indicate the system failure and that the stop bars are no longer available to support Category II/III operations.

While not the most desirable configuration, the first segment of green lead-on lights must fail to the off mode so that, in the event of failure of a single lead-on light slave unit, that green light will not be illuminated within the Black Hole during routine operations. The fail-safe mode for both of the SEA stop bar intersections is depicted in figures 15 and 16.

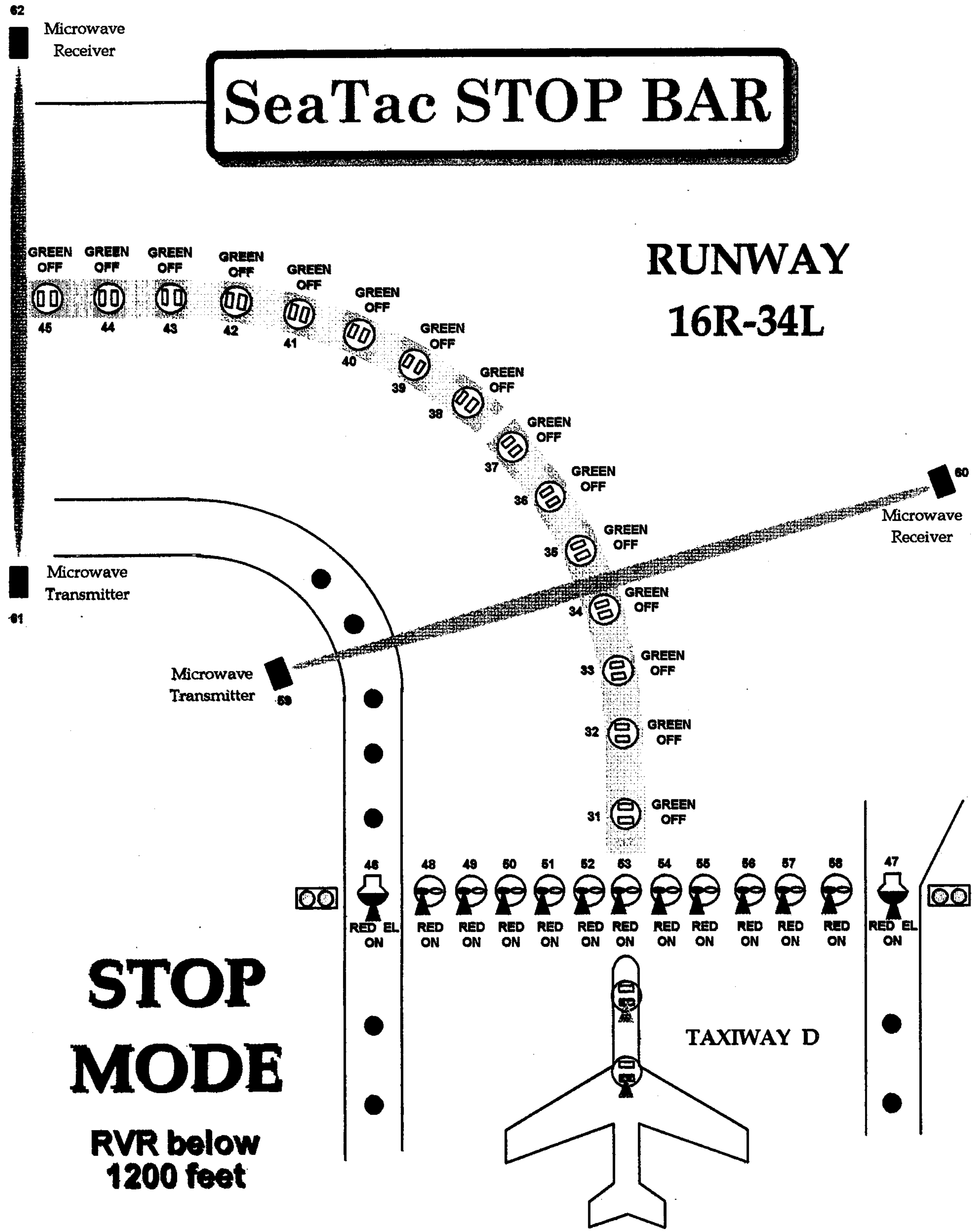


FIGURE 8. TAXIWAY D STOP MODE CONFIGURATION

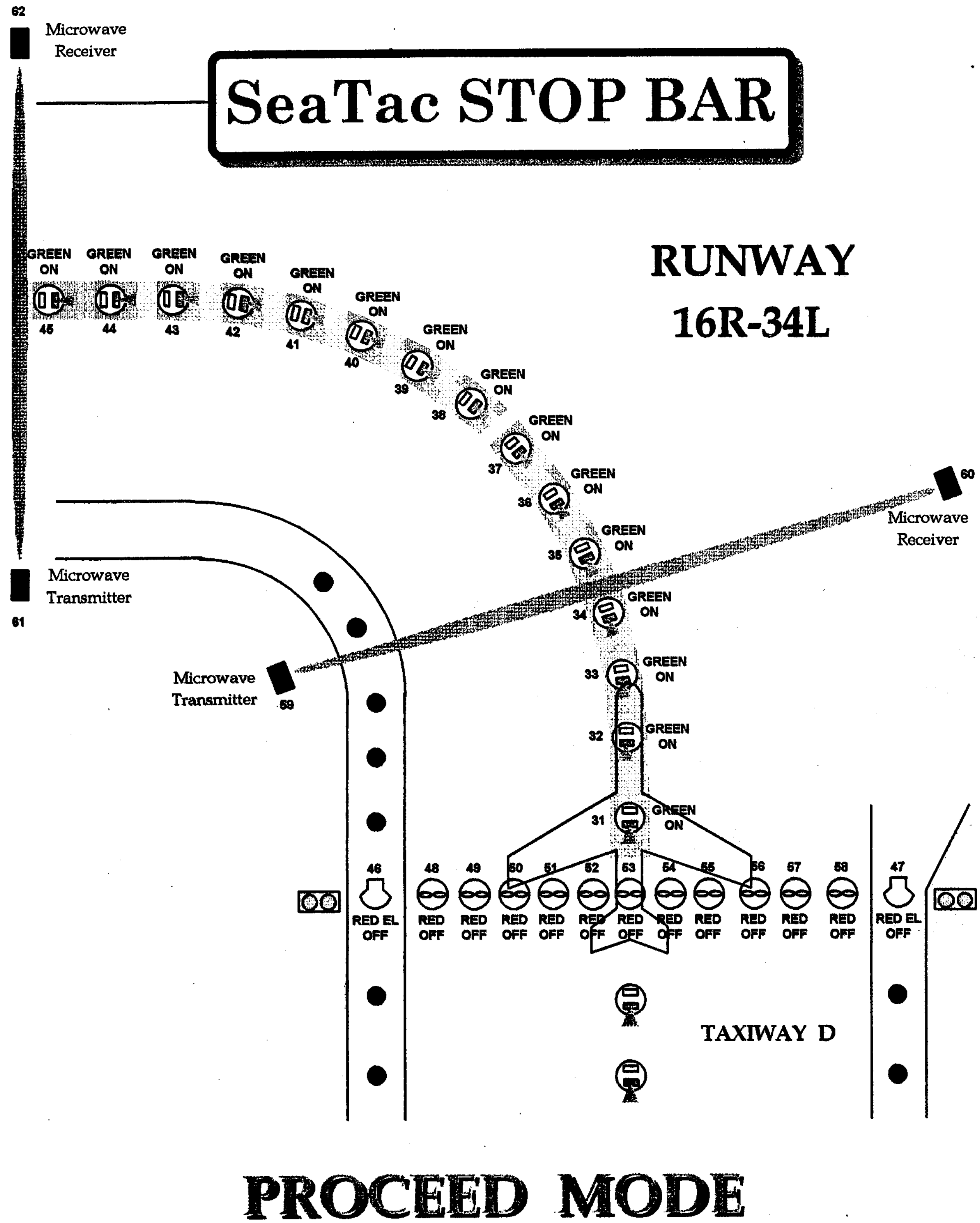
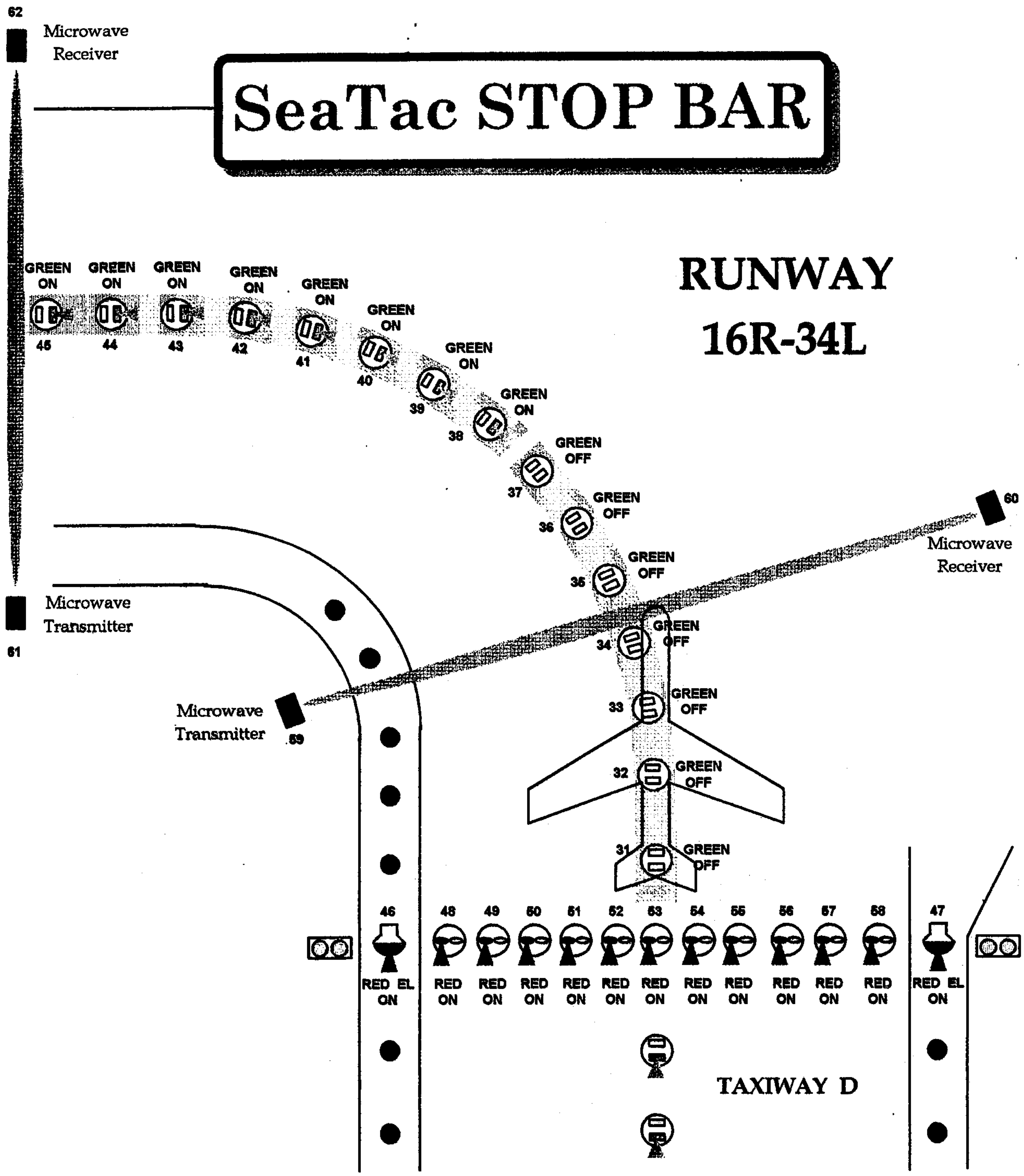


FIGURE 9. TAXIWAY D PROCEED (CLEARED) MODE CONFIGURATION



1st MICROWAVE DETECTION MODE

FIGURE 10. TAXIWAY D 1st MICROWAVE DETECTION MODE CONFIGURATION

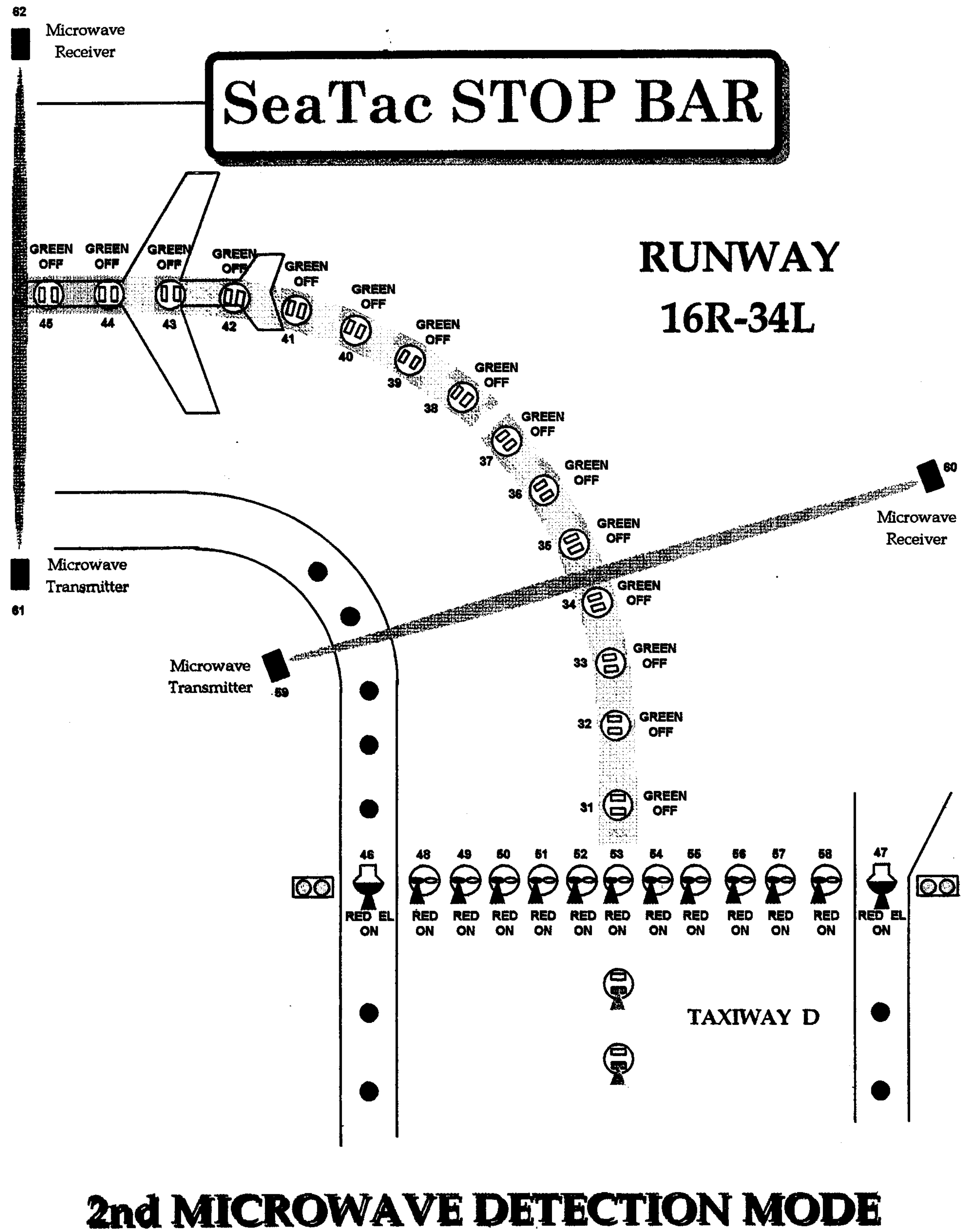


FIGURE 11. TAXIWAY D 2nd MICROWAVE DETECTION MODE CONFIGURATION

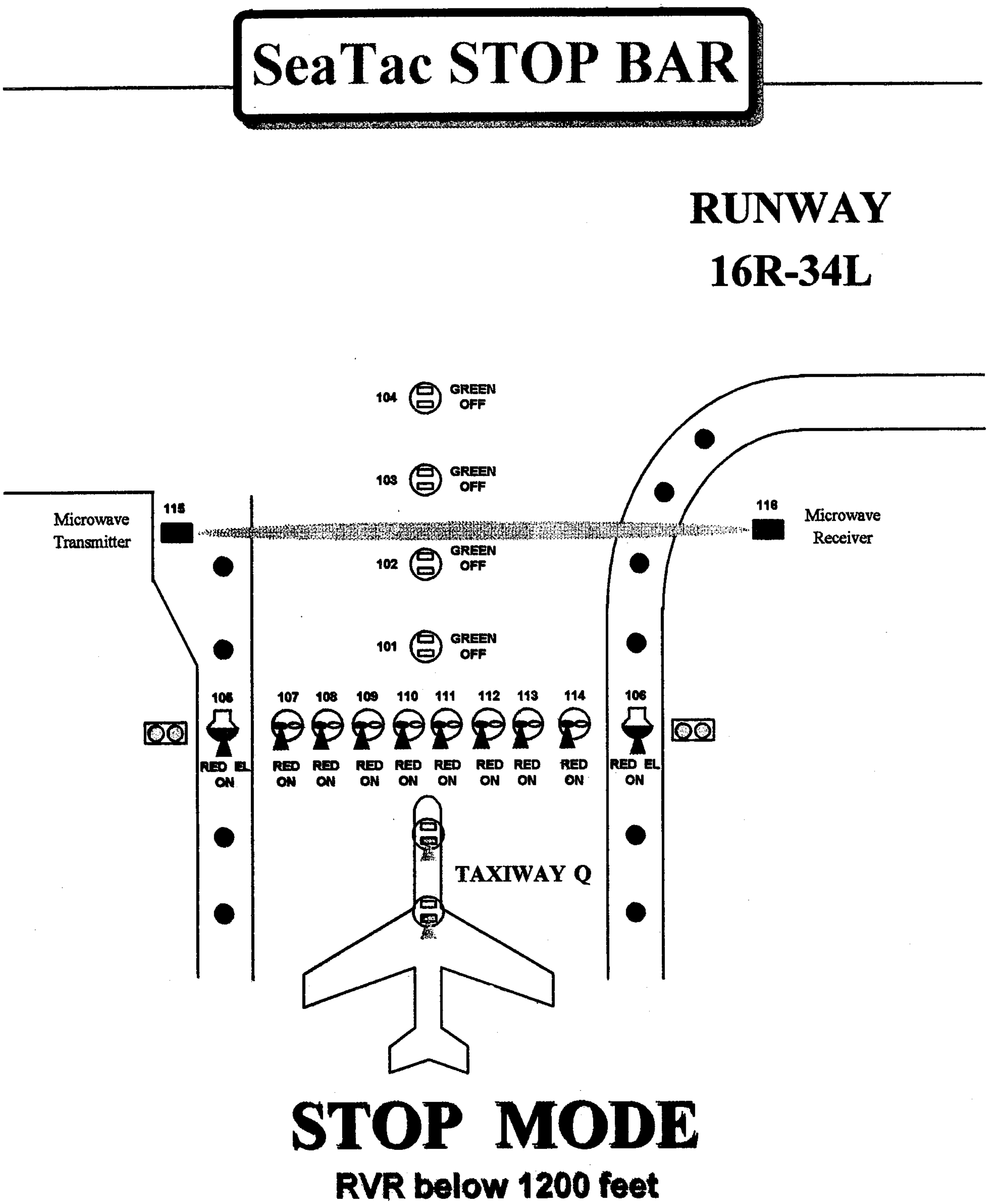


FIGURE 12. TAXIWAY Q STOP MODE CONFIGURATION

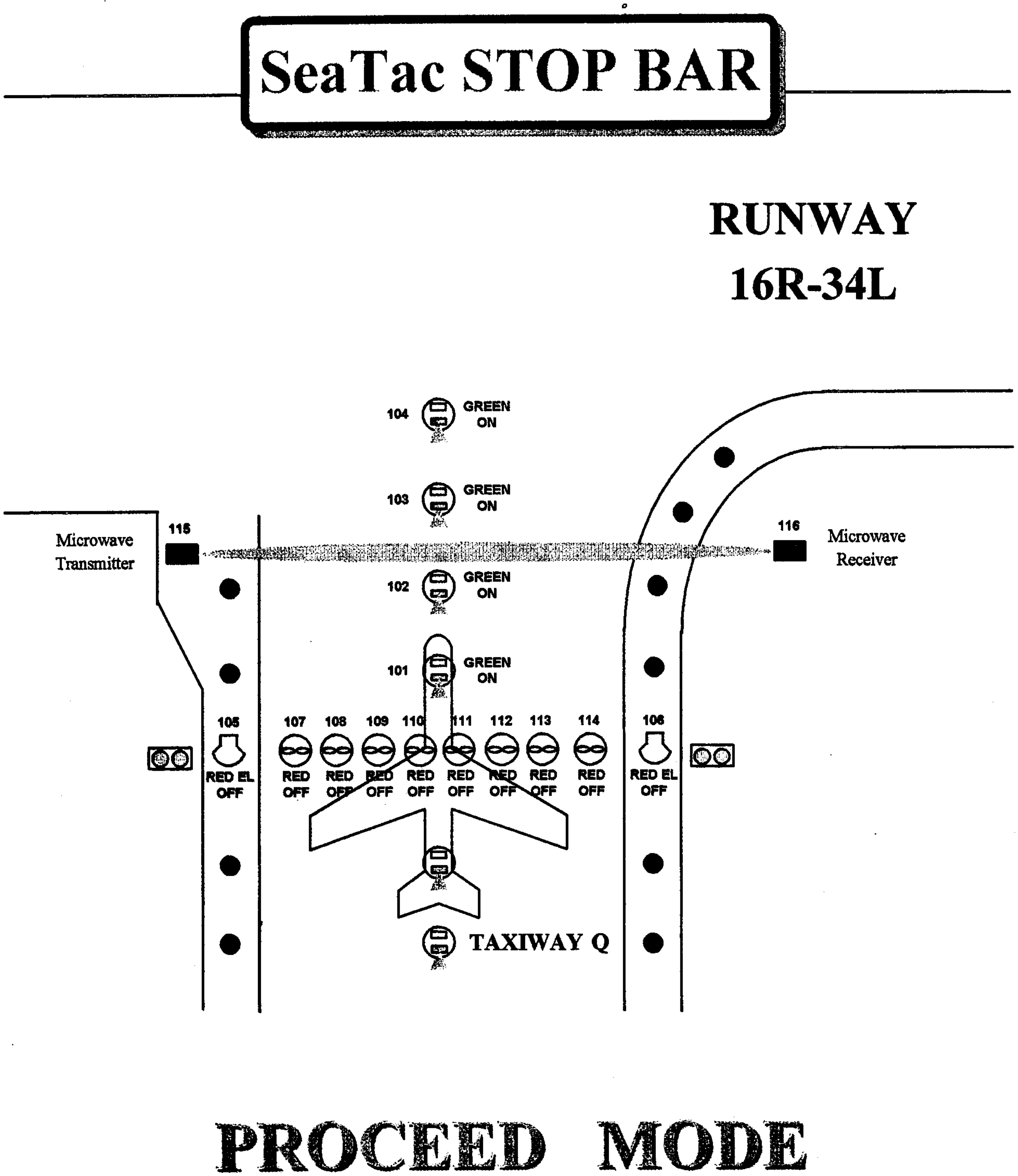


FIGURE 13. TAXIWAY Q PROCEED (CLEARED)MODE CONFIGURATION

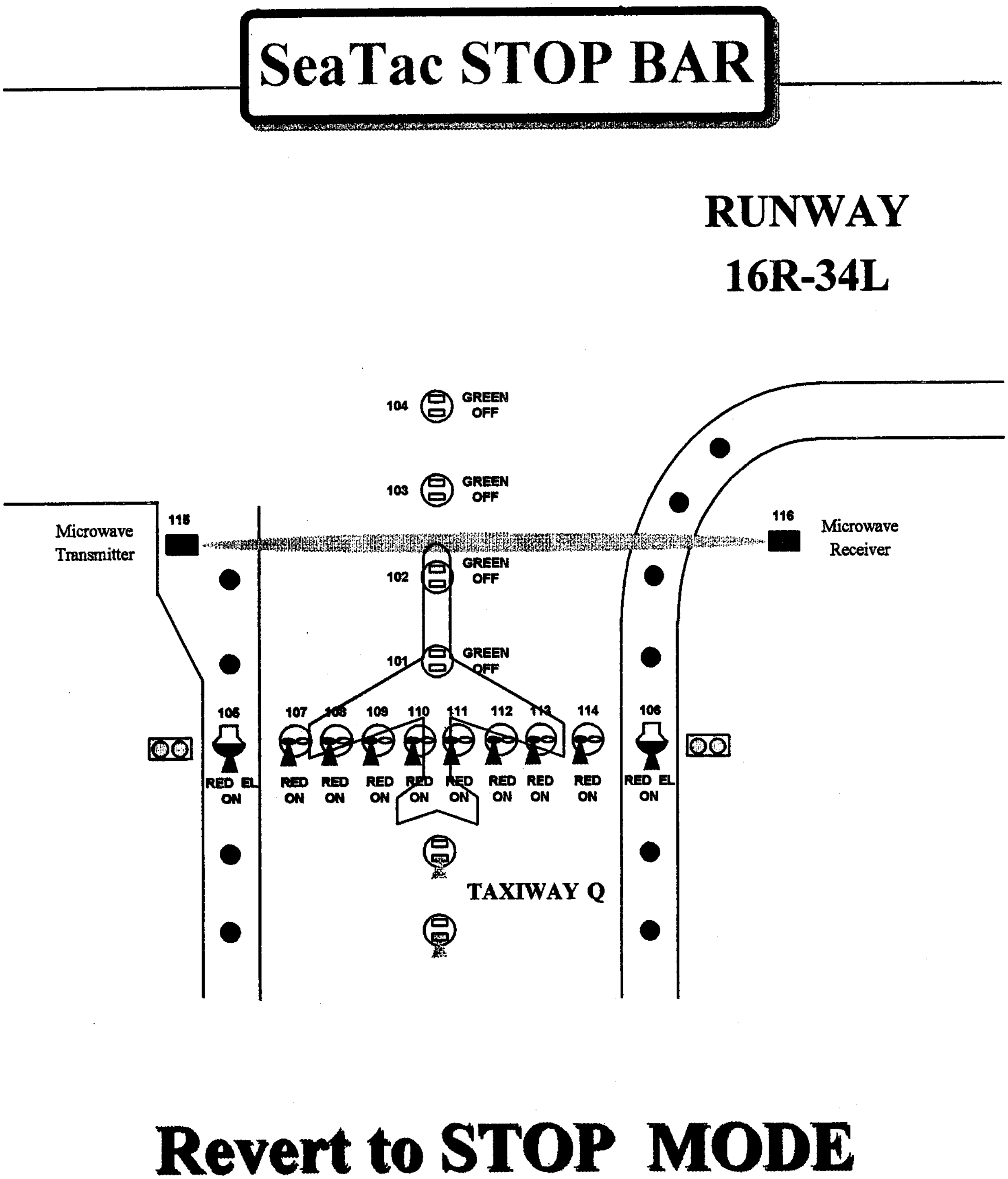
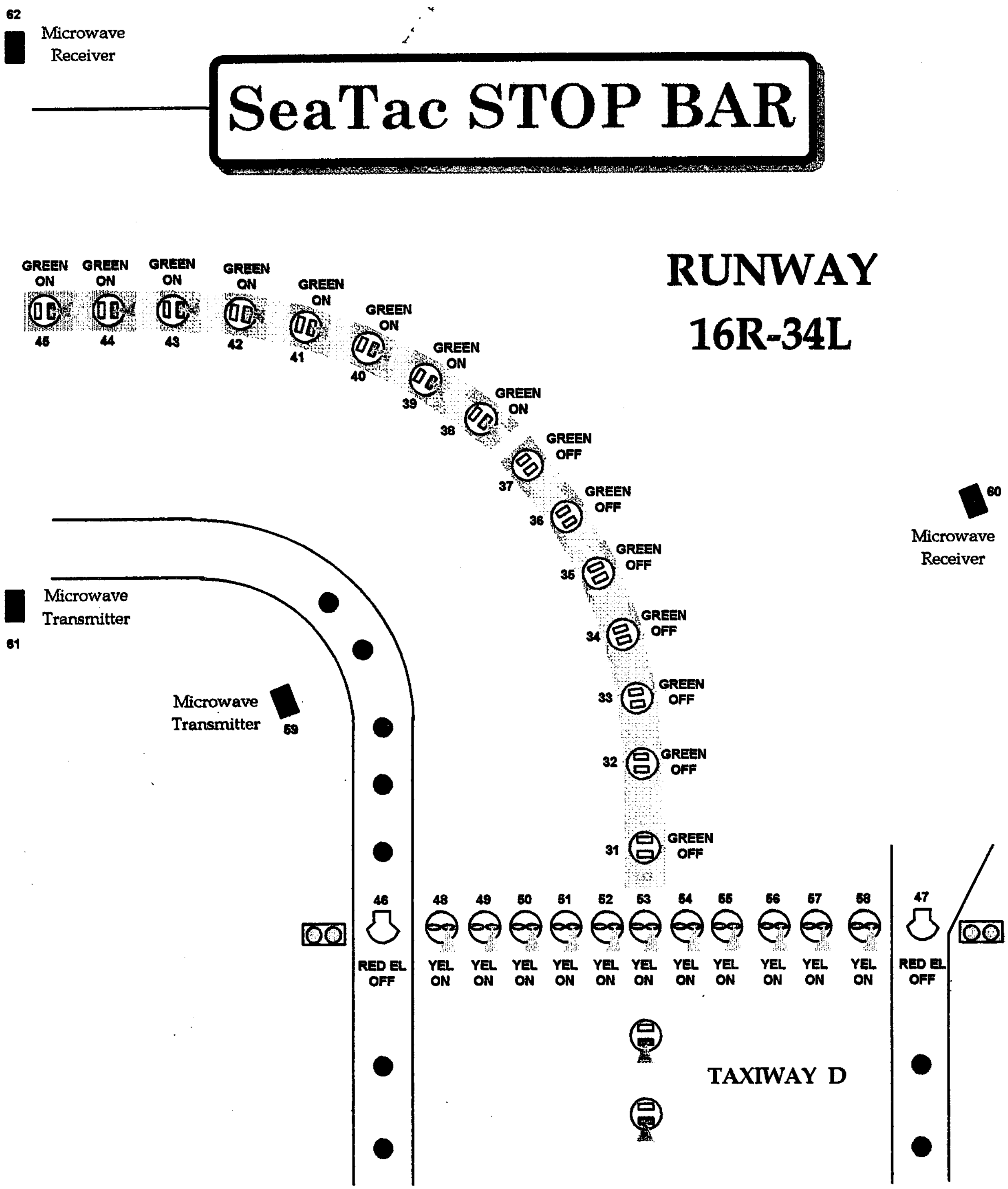


FIGURE 14. TAXIWAY Q MICROWAVE DETECTION MODE CONFIGURATION



FAILSAFE MODE

FIGURE 15. TAXIWAY D FAILSAFE MODE CONFIGURATION

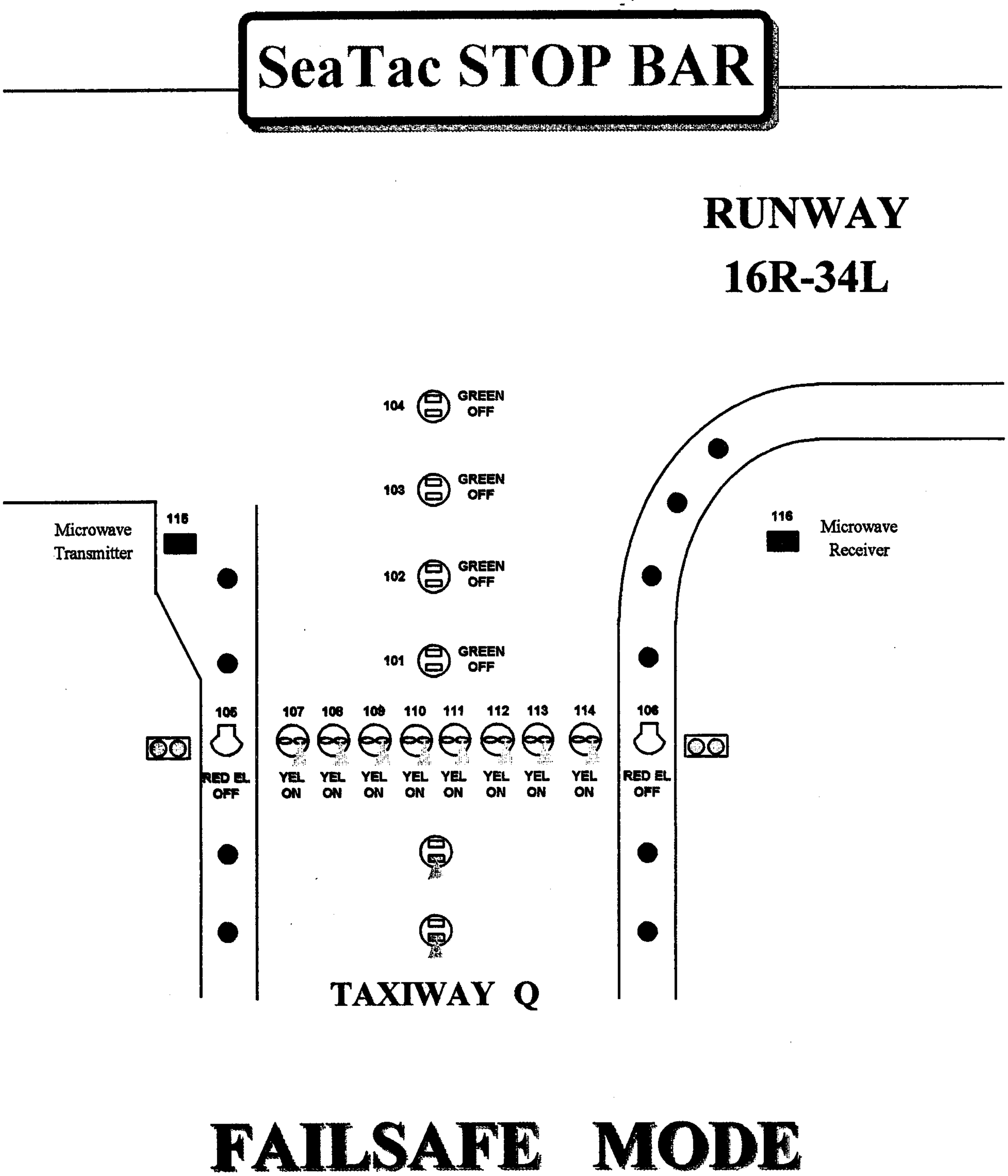


FIGURE 16. TAXIWAY Q FAILSAFE MODE CONFIGURATION

SYSTEM EVALUATION

GENERAL.

The evaluation effort involved the determination of stop bar system effectiveness and adequacy with regard to the following aspects:

1. Suitability of the stop bar lighting configuration provided at the taxiway/runway intersections. Evaluation data to be obtained principally from user pilot questionnaires.

2. Suitability of the control panel and alarm devices provided in the control tower. Evaluation data to be obtained principally from air traffic controller questionnaires.

3. Control system reliability and adequacy of computer driven maintenance aids.

The stop bar system was operated whenever low visibility conditions prevailed at SEA airport, and also during some low traffic nighttime periods to provide air traffic controller training and user pilot exposure to the field lighting presentation.

USER-PILOT OPINION.

Air carrier pilots from Alaska, American, Delta, Northwest and United Airlines were requested to complete questionnaire forms once they had gained a measure of experience with the stop bar system at SEA.

Completed questionnaire forms were collected by the locally based chief pilots of each airline and forwarded to the FAA Technical Center for analysis.

A sample of the user pilot questionnaire form is provided as Figure 17.

AIR TRAFFIC CONTROLLER EVALUATION.

Air traffic controllers at SEA were requested to complete questionnaire forms after they had received training on use of the stop bar system control panel and had been afforded sufficient opportunity to operate the system during training sessions and under actual low-visibility operational conditions.

Completed questionnaire forms were collected by the ATC Facility Manager and forwarded to the FAA Technical Center for analysis.

A sample of the air traffic controller questionnaire form is provided as figure 18.

SEA STOP BAR LIGHTING SYSTEM EVALUATION

To the User Pilot:

We are very interested in obtaining user pilot opinion as to the effectiveness of the recently installed air traffic controlled stop bar system protecting runway 16R-34L. The two stop bars are located on taxiways C-1 and C-11 (new designations D and Q, respectively) and have been installed in support of SEA's low-visibility operations. We ask that after you have had sufficient experience with system operation, you take time to fill out the attached questionnaire. We have tried to make the questionnaire as brief as possible.

THANK YOU FOR PARTICIPATING IN THIS EVALUATION!

1. How would you rate the effectiveness of this system in preventing inadvertent runway incursions?

Very Effective:_____ Marginally Effective:_____ Ineffective:_____

Comments:____

____

2. Is the system display (red/green lights) sufficiently distinctive to prevent confusion with other airport lighting systems?

Yes:_______ No:_______

Comments:____

____

3. Are the system's colors and intensities appropriate for low visibility conditions?

Yes:_______ No:_______

Comments:____

____

4. Please provide any additional comments that you might have:

____

____

Type Aircraft:____________ Air Carrier:____________________

Conditions: Day:_______ Night:_______ Reported RVR:____________

FIGURE 17. USER-PILOT QUESTIONNAIRE FORM

AIR TRAFFIC CONTROLLER QUESTIONNAIRE

SEA STOP BAR CONTROL SYSTEM

This questionnaire is intended to obtain user controller opinion as to the effectiveness and reliability of the recently installed SEA stop bar system. Please answer the following questions based upon your experience in operating the stop bar control panel serving runway 16R at SEA.

---

1. Do your consider the stop bar control panel to be reliable and user friendly? (take into account response time of panel lights)

Yes_____ Could be better_____ No_____ Insufficient Data_____

Comments:____

____

____

1a. Are the panel lights sufficiently distinguishable under a variety of lighting conditions?

Yes_____ No_____

Comments:____

____

____

1b. Is the layout of the control panel satisfactory?

Yes_____ No_____

Comments:____

____

____

FIGURE 18. AIR TRAFFIC CONTROLLER QUESTIONNAIRE FORM

AIR TRAFFIC CONTROLLER QUESTIONNAIRE (CONTINUED)

1c. Have you experienced any difficulties with the push buttons in the operation of the stop bar system? (Take into account protection from inadvertent activation, button size, and pressure required for activation.)

Yes_____ No_____

Comments:____

____

____

2. Does the stop bar implementation significantly increase the workload in the tower cab?

Yes_____ No_____

Comments:____

____

____

3. In your opinion, will the use of stop bars reduce the opportunity for a runway incursion and make the airport safer?

Yes_____ No_____

Comments:____

____

____

4. Has the stop bar implementation had any effect on air traffic flow or airport capacity?

Yes_____ No_____

Comments:____

____

____

FIGURE 18.(CONTINUED) AIR TRAFFIC CONTROLLER QUESTIONNAIRE FORM

5. Do the overall alarm provisions built into the stop bar control system software provide you with satisfactory indications of problems without undue false alarms?

Yes_____ No_____

Comments:____

____

____

6. Is the manual "clearance cancellation" feature (pushing the "clearance" push button a second time to reactivate the red lights) satisfactory?

Yes_____ No_____ Eliminate_____ Do it some other way_____

Comments:____

____

____

7. Is the automatic "clearance cancellation" feature (red stop bar lights reactivated if no aircraft movement onto the runway restores the system within 60 seconds) satisfactory?

Yes_____ No_____ Change time duration to _____ seconds

Comments:____

____

____

8. Please detail any pilot complaints that you may have received about the stop bars, lead-on lights, taxi-holding position lights, spot markings, clearance bars, etc.

____

____

Experience with the stop bar system control:

Number of low-visibility operational periods:_____
Training sessions only:_____

FIGURE 18. (CONTINUED) AIR TRAFFIC CONTROLLER QUESTIONNAIRE FORM

CONTROL SYSTEM RELIABILITY/MAINTENANCE.

SEA technicians assigned to the maintenance of airfield lighting systems assisted materially during the installation of the control and field lighting portions of the stop bar system. Every attempt was made to explain the purpose and functioning of system components as they were installed and checked out, so as to prepare the technicians for their subsequent tasks of maintaining the system after acceptance for operational use.

Representatives of the control system vendor, ADB, conducted training sessions for maintenance technicians of all three shifts. They used final-form maintenance manuals and provided hands-on practice in the detection, identification, and elimination of control system failures. Computer generated maintenance screens were provided as part of the control system software program to assist in the performance of maintenance tasks.

Since the field lighting technicians are not expected to maintain the stop bar system's computers and associated electronic devices, additional training was provided to SEA electronic technicians. It was the intent that these electronic technicians would provide support to the field lighting technicians in the event of a computer related system failure.

EVALUATION RESULTS

USER-PILOT OPINION (Stop Bar Lighting Configuration).

Pilot evaluation of stop bar system suitability, effectiveness, and potential for preventing runway incursions, as expressed in the post usage questionnaires, was overwhelmingly favorable.

Reference to the questionnaire summary sheet, figure 19, reveals that 17 of the 19 responding air carrier pilots felt that the system would be "Very Effective" in preventing incursions. The remaining two responses to this question rated the system "Marginally Effective", with no pilots rating the system as "Ineffective".

With regard to the second question, concerning possible confusion of this lighting configuration with other lighting systems found on the airport, 18 of the 19 participating pilots felt that it was sufficiently distinctive and posed no potential for erroneous interpretation. Only 1 pilot expressed an opinion that there was a possibility that the stop bar lighting display could be confused with other airport lights.

In response to the third question concerning appropriateness of the displayed stop bar signal intensities and colors, 18 pilots indicated that they found them suitable for the visibility conditions encountered during the period of operation. It might be noted that the one pilot providing less than favorable responses encountered the system under visibility conditions greater than 1200 foot RVR, and that the possibility exists that the stop bars were not activated, leaving only the holding position yellow lights illuminated. This pilots stated that "I never saw red lights. They looked sort of yellow/orange", which lends credence to the presumption that he had, perhaps, not encountered the stop bar display at all.

The forth question elicited subjective comments concerning any other aspects of the evaluation that might pertain. A summary of these comments, along with others offered in the preceding questions, is provided in appendix C.

Several comments indicated a concern with intensity of various stop bar light segments, for the most part that they might have been too bright. It should be remembered that a number of pilots were exposed to the stop bar system visual display only during training sessions conducted under relatively high visibility conditions at night, and the high intensity stop bar system lights were somewhat intense under these abnormal viewing circumstances.

Of the 27 subjective comments received, 22 were of favorable nature, 3 were unfavorable, and 2 were neutral (insufficient exposure to the system).

SUMMARY OF USER-PILOT QUESTIONNAIRE RESPONSES

1. How would you rate the effectiveness of this system in preventing inadvertent runway incursions?

Very Effective: 17 Marginally Effective: 2 Ineffective: 0

Comments: See appendix C

2. Is the system display (red/green lights) sufficiently distinctive to prevent confusion with other airport lighting systems?

Yes: 18 No: 1

Comments: See appendix C

3. Are the system's colors and intensities appropriate for low visibility conditions?

Yes: 18 No: 1

Comments: See appendix C

4. Please provide any additional comments that you might have:

See appendix C

Type Aircraft: 727, 737, 757, DC-10

Air Carrier: AK, AA, DAL, NW, USAIR

Conditions: Day; X Night: X Reported RVR: 600' - 6000+'

FIGURE 19. PILOT QUESTIONNAIRE SUMMARY SHEET

AIR TRAFFIC CONTROLLER EVALUATION (Control/Monitor Systems).

Controller evaluation of the stop bar system's suitability, effectiveness, and potential for preventing runway excursions, as expressed in the post-usage questionnaires, was not nearly so clear-cut nor definitive as was the evaluation provided by user pilots.

Reference to the controller questionnaire summary sheet, figure 20, reveals that the individual controllers held widely divergent opinions about virtually every aspect of stop bar system operation. A further look into the variety of subjective comments, as summarized in appendix D, makes it even more evident that controller reaction to operating the stop bar system was significantly influenced by such variables as amount of training received, conditions under which the system was operated, state of system tweaking or refinement, etc. The following considerations should be kept in mind while attempting to interpret or analyze controller input:

1. During the first few months of system operation after initial acceptance, a number of software and hardware modifications were accomplished to eliminate alarms and enhance system reliability. Such fine tuning is necessary whenever a new system concept is first introduced and is to be even more anticipated when the system is computer driven. Some portion of the SEA controller workforce obviously encountered some of the early-on problems, while another segment operated the system only after most of the difficulties had been resolved.

2. Controllers working with the system under low-visibility weather conditions would have been subjected to a somewhat lower density of ground traffic than those controllers who operated the system only during training sessions under better weather, but higher traffic density conditions.

It should also be noted that in recent months, subsequent to the collection of controller questionnaires, very positive controller feedback regarding the stop bar system's operation has been received through several conversations with SEA tower personnel.

SUMMARY OF AIR TRAFFIC CONTROLLER QUESTIONNAIRE RESPONSES

1. Do your consider the stop bar control panel to be reliable and user friendly? (take into account response time of panel lights)

Yes: 7 Could be better: 6 No: 4 Insufficient Data: 4

Comments: See appendix D

1a. Are the panel lights sufficiently distinguishable under a variety of lighting conditions?

Yes: 7 No: 5

Comments: See appendix D

1b. Is the layout of the control panel satisfactory?

Yes: 7 No: 3

Comments: See appendix D

FIGURE 20. AIR TRAFFIC CONTROLLER QUESTIONNAIRE SUMMARY SHEET

SUMMARY OF AIR TRAFFIC CONTROLLER QUESTIONNAIRE RESPONSES (CONTINUED)

1c. Have you experienced any difficulties with the push buttons in the operation of the stop bar system? (Take into account protection from inadvertent activation, button size, and pressure required for activation.)

Yes: 5   No: 5

Comments: See appendix D

2. Does the stop bar implementation significantly increase the workload in the tower cab?

Yes: 7   No: 9   Insufficient Data: 6

Comments: See appendix D

3. In your opinion, will the use of stop bars reduce the opportunity for a runway incursion and make the airport safer?

Yes: 9   No: 12

Comments: See appendix D

4. Has the stop bar implementation had any effect on air traffic flow or airport capacity?

Yes: 2   No: 18

Comments: See appendix D

FIGURE 20. (CONTINUED) AIR TRAFFIC CONTROLLER QUESTIONNAIRE SUMMARY SHEET

SUMMARY OF AIR TRAFFIC CONTROLLER QUESTIONNAIRE RESPONSES (CONTINUED)

5. Do the overall alarm provisions built into the stop bar control system software provide you with satisfactory indications of problems without undue false alarms?

Yes: 5 No: 11

Comments: See appendix D

6. Is the manual clearance cancellation feature (pushing the clearance push button a second time to reactivate the red lights) satisfactory?

Yes: 9 No: 5 Eliminate: 1 Do it some other way: 1

Comments: See appendix D

7. Is the automatic clearance cancellation feature (red stop bar lights reactivated if no aircraft movement onto the runway restores the system within 60 seconds) satisfactory?

Yes: 14 No: 2 Change time duration to 30 (2) / 90 (1) / 120 (1) seconds

Comments: See appendix D

8. Please detail any pilot complaints that you may have received about the stop bars, lead-on lights, taxi-holding position lights, spot markings, clearance bars, etc. See appendix D

Experience with the stop bar system control:

Number of low-visibility operational periods: Range of 0 to 15

Training sessions only: Range of 0 to 5

FIGURE 20.(CONTINUED) AIR TRAFFIC CONTROLLER QUESTIONNAIRE SUMMARY SHEET

It should also be mentioned that the questionnaire form was expanded about halfway through the one year evaluation period. All original questions were retained, and three more were added (questions 1a, 1b. and 1c) to obtain additional information about panel design and possible need for modification. As a result, totals for controller responses to individual questions will vary.

With regard to the specific questions posed, we can make the following general interpretations:

Question 1. Panel Reliability and User Friendliness

Only 4 out of 21 responses were totally negative, with an additional 4 responders stating that their experience with the panel was insufficient for judgment.

One recurring comment dealing with the control panel involved criticism of the panel location. The initial selection of locations for the two duplicate panels assumed that the controllers would need to have them very close at hand, right at the local controller's immediate front. This assumption may have been incorrect since a number of responses indicated that it would be better situated to the side and away from the work surface directly in front of the position. Since the SEA stop bar installation involves only two field locations, at the extreme ends of runway 16R/34L, and since only a minimum of attention is required to select the correct one of only two clearance push buttons, it is possible that the panels could be relocated to less intrusive sites.

The location for complex stop bar control panels at other airports having more than just a few stop bar locations may become critical in the future. As opposed to the situation at SEA, a controller needing to quickly select the desired stop bar push button from among many may well want the panel directly in front of his operating position. It is probably not possible to specify a standardized panel location for all airports, but rather, that this will have to be a tailored determination on a case by case basis.

Question 1a. Panel Lighting

Slightly less than half of the responding controllers, 5 out of 12, indicated that they did not consider the panel lights to be satisfactory. A dimming capability was provided for the panel back lighting (airfield layout mimic), but none was provided for the LED indicator lights and the clearance push buttons. These should probably be brighter and also have the dimming capability. If the various panel lights could be well coordinated or balanced, then one single dimming switch could serve all. The SEA rotary dimming control, with a rather large knob, was a

subject of criticism and efforts should be made in the future to insure that all panel control devices are as flush as possible.

One comment, to the effect that the panel should be made more compact, probably expresses an unattainable objective. Only so many push buttons, lights, alarm horns, etc., can be located on a panel that also must contain a mimic of field locations. It is obvious that, as is the case at SEA with only two stop bars, a mimic type panel may not always be required. However, other installations with perhaps many more stop bars will certainly require a mimic type display, and the panel size will just as surely be larger than the SEA prototype panel now under evaluation.

Question 1b. Panel Layout

Most of the responding controllers, 7 out of 10, indicated that they found the physical layout (orientation of switches, lights, etc.) satisfactory. The comments received in association with this question were few, and the subjects have already been discussed in connection with previous question content.

Question 1c. Panel Push Button Design

Controller satisfaction/dissatisfaction responses were evenly divided (5/5) on this subject. Two comments noted under this question involved problems with push button caps becoming dislodged. This defect should be easily remedied, however, and the responses do not seem to indicate major problems in this area.

Question 2. Controller Workload

The response to this question relating to the increase in controller workload was somewhat surprising. Over half of the controllers answering (9 out of 16) indicated that the additional task of activating the stop bars for each aircraft cleared did not increase their workload. Most of the subjective comments offered in connection with the question were negative, however. These may have been primarily responses from controllers experiencing frustration with the early period of operation of the stop bar control system, before debugging cleared up many software and hardware causes of false malfunction alarms and status change delays.

Two comments, one received under the previous question and one expressed under this one, expressed concern over the effort and/or time required to activate the stop bar system. This is somewhat confusing since only selection of the "Low-Visibility" function of the system activation switch on the main lighting control panel is required to activate the stop bar system.

Several of the comments indicated that the judgment of "no increase in tower cab workload" might only pertain so long as ground traffic in the low-visibility condition remains light. As more aircraft are Category III equipped, and air crews Category III trained, the workload might increase to a significant level. It is almost certain that an increase in the number of stop bars installed, as must occur when other runways are upgraded for use in Category III conditions, will also raise the air traffic controller workload. SEA has a relatively simple runway/taxiway layout, unlike most other major air carrier airports, and their workload level should not necessarily be considered as typical.

Question 3. Stop Bar Contribution to Airport Safety

The majority of responding controllers, 12 out of 21, indicated that they did <u>not</u> think that the stop bar system will contribute to runway incursion reduction, nor provide increased safety on airports. Many of the comments relating to the question were also negative or, at best, neutral. Controllers appeared very concerned about the effort required for operation of the stop bars and the attendant distraction from their principal task of handling traffic. This may well be due to their experiences operating the system, for training, during good visibility weather conditions. Under those circumstances, when ground traffic separation is maintained by visual means, it is understandable that they would reject any requirement for diverting their attention from the world outside of the tower. On the other hand, when used in the design environment, the Category III low-visibility situation, the stop bar system may well be recognized by controllers as a positive aid to safety. It appears that there has not yet been sufficient controller experience with these operations for a valid determination to be made.

Unfortunately, as with development and use of other airport visual aids, only historical experience with stop bars over a prolonged period and a perceived reduction in instances of runway incursion incidents and accidents is experienced will they establish their true contribution to airport safety.

Question 4. Effect on Airport Capacity

With 18 out of 20 controllers expressing the belief that the implementation of the stop bar system at SEA has not adversely affected traffic flow or capacity, it would appear that delays due to stop bar system usage are not an issue. Once again, though, it should be noted that the low-visibility (Category III) capable traffic level at this airport is still rather limited, and that, as the number of users increases towards maximum capacity, any adverse affects of required stop bar usage may become more evident.

Question 5. System Malfunction Alarm Provisions

The majority of responding controllers (11 out of 16) expressed some dissatisfaction with the alarm provisions designed into the stop bar control system.

Some comments received were rather general in nature and spoke to the non-system problem of too many alarms in towers having a multitude of electronic systems, each with its own malfunction warning. The several other notations of stop bar system false alarms may have been occasioned, as indicated heretofore, by initial software and hardware problems that have since been corrected.

Yet another comment mentioned that once the alarm sounds, it is not easy to identify the fault causing it. This is somewhat difficult to interpret, since the control system alarm design includes a provision for blinking or pulsing the indicator LED lights associated with the segment of the system (stop bar lights, lead-on lights, etc.) experiencing problems. It should be sufficient to identify a malfunction condition to the controller, so that he may immediately notify the maintenance personnel charged with restoring the system to service.

Question 6. Clearance Cancellation Feature

Most controllers (9 of 16) felt that this feature had been satisfactorily incorporated into the control panel design.

Very few comments specifically speaking to this issue were received, although 3 controllers did express a desire for a separate "kill switch" rather than using a second activation of the clearance push button to cancel the commanded status change. In view of the fact that more complex control panels will certainly be used in the future, the provision for the separate cancellation function may be advisable, especially since it may be necessary to cancel more than one stop bar operation in an emergency situation. The suggestion appears to have merit.

Question 7. Automatic Clearance Feature

This feature, to effect automatic restoration of the stop bar red signal whenever sensors do not detect vehicular (aircraft, truck, etc.) passage after a 60-second period, was judged as satisfactory by 14 of 16 controllers responding. However, a total of 9 subjective comments were received addressing the time duration aspect, with opinion evenly divided between lengthening and shortening the duration of the delay period.

It seems clear that the concept of automatic cancellation is valid, but it also appears that no specific delay duration can be provided.

Variables such as ramp/runway taxi route length, ground traffic density, controller techniques, and several other factors all combine to make determination of an all-airport fixed delay period virtually impossible. In fact, it is very likely that delay times for different stop bar locations at a single airport will be different and that a means for adjusting the delay period will have to be provided for each individual stop bar location.

Question 8. Pilot Complaints

It was intended that this question would provide controllers with an opportunity to pass along any comments about the stop bar system that might have been received via radio from user pilots. Apparently very few pilot comments were received, since several controllers expressed the belief that the system was too new and that the pilots were not sufficiently familiar with it to voice opinions over ATC communications frequencies. While this may be the case, it may also be that the pilots were, in fact, well enough informed about the stop bar operation and that they were experiencing no difficulty with it. The relatively favorable responses received on the user pilot questionnaires, provided earlier in this report, would seem to substantiate this interpretation.

One controller reported some pilot confusion during times when the stop bar system was being operated under VFR conditions for maintenance training and familiarization purposes. No details of this problem have been provided, but it must be assumed that this extraordinary operation of the system was noted on the local Automatic Terminal Information Service (ATIS) announcements and that operation of the system was controlled so that no pilots were issued clearances to cross illuminated red stop bars.

CONTROL SYSTEM RELIABILITY/MAINTENANCE.

During the one-year period of operation, subsequent to stop bar system check-out and acceptance, SEA maintenance technicians were called upon frequently to resolve hardware malfunctions that resulted in failure alarms in the tower cab. It was anticipated that some considerable effort would be required to debug what was, essentially, a conceptually novel and unique airfield visual system, and such was the case.

Under the terms of the control system vendor's warranty, the ADB company responded to SEA requests for technical assistance in resolving maintenance problems and provided on-site support as required. Problems identified and corrected included the following:

Premature Slave Failures - A number of slave power supply components failed shortly after installation, causing tower alarms to be generated and necessitating replacement of individual slave units.

These failures appeared to be a result of power cable voltage spikes or surges affecting weaker components within the ungrounded slave power supplies. Continuous grounding of all slaves should eliminate this problem.

Microwave Detector Interference - Shortly after the system was accepted and placed in operational status, numerous microwave detector problems were experienced. These apparently resulted from spurious radiation signals emanating from other electronic devices located on or near the airport. Narrow band filters subsequently retrofitted to each microwave receiver antenna circuit eliminated the problem.

System Activation Alarms - Initially, short-term system failure alarms were frequently encountered immediately subsequent to stop bar system activation for use. The occurrence of such alarms, even though of only momentary duration, was most distracting to controllers and provoked considerable dissatisfaction with the overall system. The problem was determined to be a result of delayed responses from individual slaves during the monitor polling process that caused alarms to be generated once the design 2-second delay period was exceeded and then self-cancelled once polling was completed momentarily thereafter. Introduction of a 10-second alarm delay, to provide sufficient time for all slaves to respond, eliminated this problem. The software change did not affect the time (2 seconds) required to detect alarm conditions while the system was in the steady state status, i.e., not in the short term process of changing the display after receiving the clearance command. Thus, the 2-second alarm requirement remained satisfied for all but very short periods of system operation.

It is the nature of the stop bar system operational concept that it will be used only infrequently, during occurrences of extremely low-visibility (Category II/III) weather conditions. The design of the control system installed at SEA was such that alarms were disabled whenever the stop bars were not activated, under the assumption that maintenance personnel would be conducting scheduled periodic checks to determine system availability and operational status. Unfortunately this periodic maintenance check was not incorporated into the scheduled routine right from the start, and the system remained inactive and unchecked for relatively long periods of time between Category II/III weather occurrences. As a result, minor system failures, such as lamp outages, occurred and persisted without identification until such time as the stop bars were activated. These accumulated faults then generated tower alarms immediately after the system was activated.

Weekly maintenance check routines have been implemented, and ATC personnel have been instructed to conduct weekly exercise sessions with full stop bar system operation during low-traffic periods. This policy should significantly reduce that occurrences of system activation alarms and insure that component failures are detected and corrected on a timely basis.

CONCLUSIONS

From the results of this developmental/evaluational effort, it is concluded that:

1. The draft stop bar specification, to include theory of operation and control techniques, provides sufficient guidance for the development and implementation of a stop bar system within the National Airspace System (NAS).

2. The prototype stop bar system was successfully installed at a major air-carrier airport for testing and demonstration purposes.

3a. The basic U.S. stop bar lighting configuration, as developed and described in the draft stop bar specification, Interim Specifications for Stop Bar Installations, Chapter 1, is satisfactory and acceptable to user pilots.

3b. The guidance contained in Chapter 2 of the draft stop bar specification, Remote Control Panel, is essentially correct. However, certain specific specification details, such as panel dimensions, use of light emitting diode (LED) indicators, push-button characteristics, etc., may be too restrictive.

    Control panel location in the ATC tower cab is critical for acceptance by controllers, and every effort should be made to solicit user input before a final location is decided upon. If the panel is to be located in the controller's immediate work area, consideration should be given to providing some form of protective cover for the panel during periods when the stop bar system is not in use. If the airport requires only a minimum number of stop bars, as at SEA, consideration should be given to providing the controllers with roamer or remote clearance push-button devices, to be attached to the belt, allowing the control panel to be located away from the controllers work station.

4. The current-carrier stop bar control system, as installed for the prototype system at SEA, provides an economical and reliable means for retrofitting the stop bar system at existing airports. However, periodic maintenance checks and ATC exercising of the stop bar system are essential to maintaining system integrity. The fact that long periods of time may pass between operational usages in relatively infrequent Category II/III weather conditions mandates disciplined maintenance efforts to insure that this critical system will be available for use immediately upon occurrence of low-visibility conditions.

APPENDIX A

DRAFT FAA STOP BAR SPECIFICATION

DRAFT

INTERIM SPECIFICATIONS FOR STOP BAR INSTALLATIONS

MAY 15, 1992

(Revised 12/1/92)

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

TABLE OF CONTENTS

CHAPTER 1. STOP BAR CONFIGURATION

CHAPTER 2. REMOTE CONTROL PANEL

CHAPTER 1. STOP BAR CONFIGURATION

1. GENERAL. Stop bars can help prevent runway incursions by providing pilots with visual confirmation of ATC clearances to taxi onto or cross runways. Runway incursions occur most frequently under good visibility daytime conditions, but most major accidents have occurred under low visibility conditions. A properly designed stop bar system is an essential component of a surface movement guidance and control system necessary for the safe and efficient operation of an airport.

It should:

a. Indicate certain mandatory holding positions.

b. Identify boundaries for ILS critical areas and runway safety areas/obstacle-free zones (OFZ).

c. Provide pilots with a visual confirmation of the Air Traffic Control (ATC) clearance to proceed onto or to cross an active runway.

d. Prevent aircraft from entering an active runway without ATC clearance.

2. PLANNING. Readers of this preliminary draft specification should recognize that several stop bar evaluations are recently being performed or are about to be performed. The results of these evaluations will have a significant impact on all guidance contained herein. The Federal Aviation Administration (FAA) recognizes that airports may wish to decrease stop bar installation costs by installing transformer housings and conduit for taxiways/runways presently under construction. However, critical details such as fixture beam spreads, light intensities, physical circuitry, and especially the remote control panel are very preliminary. Therefore, airport operators would be prudent to postpone completion of their stop bar system until these details are solidified.

3. CONFIGURATION.

a. Description.

The stop bar consists of a single row of flush or semiflush inset lights installed along the runway holding position marking with an additional elevated light on each side located off of the full strength pavement. Controllable stop bars have an associated segment of taxiway centerline lights (lead-on lights) located between the stop bar and the runway centerline.

b. Stop Bar Lights.

(1) Location. The lights are located a maximum of 2 feet in front of the holding position marking (away from the runway). The stop bar fixtures are arranged so as to be symmetrical to the taxiway centerline lights and spaced laterally across the entire taxiway (including any fillets, holding bays, etc.) at 9 foot, 10 inch (3 m) intervals. Each light may be offset a maximum of +2 feet (+0.6m) to avoid rigid pavement construction joints or other undesirable locations. Where a stop bar is to be installed at a location where both a runway safety area/Obstacle Free Zone holding position and an ILS Critical Area Holding Position exist, a maximum of one stop bar shall be installed, located at the ILS Critical Area Holding Position.

(2) Stop Bar Fixtures. AC150/5345-46 will be revised to include specifications for in pavement and elevated stop bar fixtures. All stop bar fixtures are unidirectional.

(3) Elevated Stop Bar Lights. Elevated stop bar lights, located at the taxiway edge, must be provided at all stop bar locations to provide continuous indication of the holding position after cockpit cutoff prevents pilot observation of the in-pavement stop bar lights. These elevated lights also provide enhancement of the stop bar signal during periods of snow accumulation that might obscure the surface stop bar lights. These lights are located in-line with the in-pavement stop bar lights and are located 6 1/2 feet (2m) from the edge of the full strength pavement on each side of the taxiway.

(4) Intensity. The intensity of the red stop bar lights must be bright enough to be easily seen by taxiing aircraft and not too bright as to confuse pilots that may be exiting the runway by mistaking the red reflection glow of the opposing stop bar as a signal to stop.

c. Lead-On Centerline Lights. These are always installed in conjunction with controlled stop bars. They are always green.

(1) Location. The lights are located on the designated centerline of the taxiway between the stop bar and the runway centerline. The lead-on lights may be offset a maximum of 2 feet (0.6m) to avoid rigid pavement construction joints of other undesirable locations. This tolerance should be applied consistently to avoid abrupt and noticeable changes in guidance; i.e., no "zigzagging" from one side of the centerline to the other. If a tolerance is applied to the taxiway centerline lights on the side of the stop bar opposite the runway, this same tolerance should be maintained for the lead-on taxiway centerline lights. The line of lights should only cross the marking where it is unavoidable, such as at a

point where taxiway directions diverge (i.e., at a "fork" in the taxiway). Lead-on lights need not be installed at those stop bar locations that are designated as "uncontrolled". However, a prudent design would provide for future installations and control of lead-on lights at such locations.

(2) Spacing. The lead-on lights should be spaced as shown in AC150/5340-19. The lead-on lights may be offset a maximum of 10 percent of the specified maximum spacing to avoid construction joints or other undesirable locations.

d. Lead-Off Lights.

(1)Lead-off lights are not part of a stop bar system. They are addressed in this document because their presence may impact on the "black hole" effect created by a stop bar system.

(2) If lead-off lights are located at an intersection where a stop bar is present, the back side of the lead-off lights must either be controllable or rendered invisible to the aircraft located at the stop bar.

4. DESIGN

a. Theory of Operation.

(1) Stop Bars. Stop bars will be located at all lighted taxiway/runway intersections providing access to runways intended for use under instrument conditions of less than 600 RVR (Runway Visual Range). Only the controlled stop bars on the low visibility routes will be controlled by air traffic. All system stop bars, both controlled and uncontrolled, will be energized whenever the stop bar system serving a given active runway is selected.

(2) Lead-on Lights.

a. ONTO the runway - The green lead-on taxiway centerline lights located in the area between the stop bar and the runway centerline are considered to be an integral part of the stop bar system. The first segment of lead-on lights shall be de energized whenever the associated stop bar is illuminated [see (3) below for discussion of sensor segments]. Conversely, these lead-on lights shall be illuminated whenever the stop bar is de energized to permit aircraft access to the active runway. The "Black Hole", created by having the lead-on lights de energized whenever the stop bar is illuminated, serves to reinforce the stop bar signal and provides an additional positive indication.

b. ACROSS the runway - To cross a runway, green lead-on lights are used from the stop bar to the edge of the runway and may continue to the centerline of the runway itself. At that point they become lead-off lights (see 3.d).

(3) Sensors. A sensor system will be provided to detect aircraft or vehicle motion past the stop bar for the purpose of reactivating the stop bar lights to prevent incursion by following aircraft or vehicles. The sensor system should be interlocked with the stop bar presentation. Sensors need not be installed at those stop bar locations that are designated as "uncontrolled". As indicated above, however, provision for future use as a "controlled" installation should be incorporated into the initial system design. The first sensor should be located at a distance (present data suggest 50m or 164 feet) beyond the stop bar sufficient to restore the red light signal for aircraft or vehicles following the cleared one. The second sensor should be close enough to the far end of the interlocked segment so that the pilot of the aircraft entering the runway will have the guidance from the lead-on lights within the runway confines. (present data suggest 8 m or 26 feet from the point of tangency of the lead-on lights and the runway centerline) A backup timer should be installed to default the system back to the stop bar "red" configuration. The timer should be set so that it activates only in a very unusual sequence of events, i.e. a ground vehicle crosses the stop bar but does not proceed to the first sensor.

(4) Termination of Stop bar Operations. When low visibility operations are terminated, the controller will deactivate the stop bar system using the master controls. (The red stop bar lights will go off, and other movement area lighting will be turned back on.)

b. Control (Command and Monitor) Techniques.

The control/monitor system selected shall have the capability of directly monitoring the correct activation or deactivation of stop bars and lead-on lights, and of confirming that the control signal has been successfully transmitted within two seconds after initiation of the command by ATC. This response time requirement will apply regardless of the number of successive system status changes commanded.

In the event of a problem within the stop bar system, the design shall be such that any stop bar affected by the fault will "fail-safe", i.e., the status of the stop bar concerned will default to a "stop bar - off"/"hold bar (if installed) - on" condition. The first segment of lead-on lights will default to an "off" condition, and the second segment of lead-on lights will default to an "on" condition.

Since each stop bar installation will involve designing to suit individual and unique airport runway and taxiway configurations, each will have to be "tailored" for the local situation. Any one, or possibly combinations of more than one, control technique may be utilized depending upon the availability or unavailability of existing field equipment.

Among the several techniques possible, the following are cited as worthy of consideration:

(1) <u>Hardwire Control</u>. Use of existing or newly installed control cabling to carry the command and monitor (c/m) signals from the lighting vault to the various stop bar installation sites.

(2) <u>Radio Remote Control</u>. Use of VHF/UHF transceiver to transmit and receive c/m signals directly between the tower and the stop bar installation sites.

(3) <u>Control by C/M Signals Carried on Power Cables</u>. Transmission of c/m signals by superimposing them upon existing field lighting loop cables.

(4) <u>Fiber Optic Control</u>. Use of signals carried by newly installed fiber optic devices to carry c/m signals from the vault to the stop bar installation sites.

As indicated earlier, the selection of c/m technique to be used will depend on multiple factors such as cost, existing facilities and equipment, potential interference sources, etc.; and cannot be specified in this specification. Such a determination can only be made by the designer having responsibility for the specific airport or runway stop bar installation.

(5) <u>Summary of Stop bar Operations</u>:

(a.) When low visibility operations are initiated, the controller will activate the stop bar system using the master controls. (The red stop bar lights will come on, and the interlocked green lead-on lights are off) Only the Low Visibility Route is illuminated.

(b.) When a clearance to cross a runway is issued to a pilot at a stop bar, a controller will turn off the stop bar, and the interlocked segment of the green lead-on lights will come on. This visual confirmation is valid only after having received a verbal clearance.

(c.) When the first sensor is activated, the stop bar will turn back on and the first segment of interlocked lead-on lights will turn off automatically. The second set of interlocked lead-on lights will turn off once the aircraft has activated the last sensor at the far end of the interlocked segment.

(d.) When low visibility operations are terminated, the controller will deactivate the stop bar system using the master controls. (The red stop bar lights will go off, and other movement area lighting will be turned back on.)

CHAPTER 2. REMOTE CONTROL PANEL

1. BACKGROUND. Controllers will activate all stop bars with a master switch, and turn off selectivity switchable stop bars when a clearance to cross a runway is given. Procedures for stop bar operations are being developed separately and will address operating conditions. Standards for the stop bar control panel are provided in Section 3 below.

2. STOP BAR CONTROL PANEL DESIGN STANDARDS.

a. Master Controls.

(1) The master controls that will allow controllers to activate and deactivate the stop bar system (such as at the beginning or end of low visibility operations) will be located on the main lighting control panel in the tower.

(2) The master controls should require two actions to either activate or deactivate the stop bar system, to preclude accidentally turning the stop bars on or off.

(3) In the case of airports which use different taxi routes for 1200' RVR vs. 600' RVR, there should be a separate control for each configuration on the master control panel.

b. Stop Bar Control Panel.

(1) Layout. The stop bar controls and displays will be on a mimic panel (a schematic diagram of the airport movement area) because such location coding optimizes accuracy of control operation and interpretation of the displays.

(2) Content.

a. The mimic diagram should be limited to relevant portions of the movement area (i.e., designated taxi routes for low visibility operations, or, at a minimum, runways and associated stub taxiways) in order to reduce clutter and save space in the tower.

b. When there are split tower operations which would never under any circumstances be combined, portions of the movement area not applicable for a certain position do not need to be included on the panel diagram.

c. The diagram should allow for the potential inclusion of additional stop bar controls and displays.

(3) Dedicated Panel. Stop bar control and status will be provided on a mimic panel which is separate from the main airport lighting control panel.

(4) Dimensions. The mimic panel dimensions are between 4" X 12" and 8" X 12".

(5) Location. Panels should be located in the same relative location for each position if possible. Locations of control panels will have to be site specific, based on operations, space, etc.

c. Stop Bar Controls/Displays.

(1) Function. Individual stop bar controls will allow controllers to turn any controlled stop bar on or off whenever the stop bar system is activated.

(2) Controls. Stop bar controls should be push buttons (see e. for details).

(3) Display Meanings/Colors.

a. Stop Bars. Each stop bar position should be represented by 3 red light emitting diodes (LED), which will represent the on or off status of the actual stop bar, i.e., on or off when the actual stop bar is on or off.

b. Lead-on Lights. Each switched segment of the lead-on lights will be represented by one green LED located between the representation of the runway and the red stop bar LED. The green LEDs will be on while its respective segment of interlocked lead-on lights are on, and will be off when its respective segment is off.

c. Display Illumination. It is important that indicator lighting be bright enough to allow lit, or "on", displays to be readily discriminated from the "off" condition under all tower lighting conditions.

(4) Reset Capability. If, for any reason (i.e., the controller makes an error and turns off the wrong stop bar, a non-aircraft vehicle is cleared to cross the stop bar but does not intend to proceed to the sensor location, etc.), the controller needs to turn the stop bar on after he has turned it off, but before the sensor or back-up timer would take effect, he can activate the stop bar control (pushbutton) again to turn the stop bar back on.

d. Stop Bar Alert Control/Displays.

(1) Alert Function. The alert will indicate that stop bar lights are malfunctioning when the following conditions exist:

a. A discrepancy exists between the stop bar system status and the controller or sensor system commands.

b. For stop bar in pavement lights: more than three unserviceable or two adjacent lights unserviceable.

c. For elevated stop bar lights: one light out.

d. Lead-on Lights: two adjacent lights unserviceable.

e. If electronic monitoring becomes inoperable, visual inspection may be performed as indicated in the SMGCS Advisory Circular.

(2) Alert Control. A single control will be used to acknowledge an alert of a stop bar malfunction. The control will be a red backlit pushbutton. The controller can acknowledge the alert by pushing the control button.

(3) Alert Control Location. The alert control will be located in the upper right corner of the stop bar control panel.

(4) Indicators.

a. An alert will be indicated by the red alert pushbutton lighting and blinking, the appropriate stop bar red or lead-on light green LED indicator blinking, and by an audible tone.

b. When the alert pushbutton is pushed, the tone will stop and the pushbutton will stop blinking, although it will remain lit until the problem is corrected. The stop bar or lead-on light indicator will continue to blink until the problem is corrected.

c. Subsequent stop bar malfunctions, which occur prior to resolution of the first one, will cause the alert pushbutton to blink again and will produce the audible tone again. In addition, any affected stop bar red LED indicator will blink.

e. Push buttons.

(1) Tactile Feedback. Activation of a pushbutton will result in positive feedback, such as tactile feedback (i.e. a "click" feel), to the controller.

(2) Inadvertent Activation. Controls should be designed to minimize the possibility of inadvertent activation. The ranges provided below are general guidelines for pushbutton controls. The values to be used in a tower should first be validated using controller input.

a. Dimensions: Min. 9.5 mm - Max. 25 mm (3/8" - 1")

b. Separation: Min. 13 mm - Max. 50 mm (1/2" - 2")

c. Resistance: Min 2.8 N - Max 11 N (10 oz. - 40 oz.)

d. Displacement: Min. 2 mm - Max. 6 mm (5/64" - 1/4")

f. Labeling.

(1) Size. For a viewing distance of 0.5 m - 1.0 m (19.7" - 39.4") the minimum character height is to be 4.7 mm (0.18"). Alphabetic characters should be all capital letters.

(2) Font. Labels will be in a simple, unadorned font.

(3) Placement. Labels should be located in consistent locations relative to each control/display. The relationship between a label and its associated control/display should be unambiguous by virtue of their relative locations.

(4) Movement Areas. All movement areas represented on the mimic panel will be labeled according to what each area is called on airport layout charts and airport signs.

(5) Stop Bar Displays/Controls. Stop bar displays and controls do not have to be labeled since their location on a labeled mimic panel will provide unambiguous information as to the associated stop bar. If necessary, to clarify relationships between controls and displays, a line in a contrasting, neutral color can be drawn around each associated pair of controls and stop bar indicators.

(6) Stop Bar Alert Control. The stop bar alert control will be clearly labeled.

APPENDIX B

STOP BAR CONTROL SYSTEM

MANUFACTURER'S DESCRIPTIVE MATERIAL

STOP BAR CONTROL
SURFACE MOVEMENT GUIDANCE
BRITE*

ADB
A Siemens Company

1227E

COMPLIANCE WITH STANDARDS

ICAO : In compliance with recommendations for A-SMGCS.
FAA : Approved for use as Stop Bar control and monitoring system according to AC 150/5340-XX dated May 12, 1992 ; manufactured to current version of Advisory Circular 120-57. In full compliance with the A-SMGCS ASTA concept.

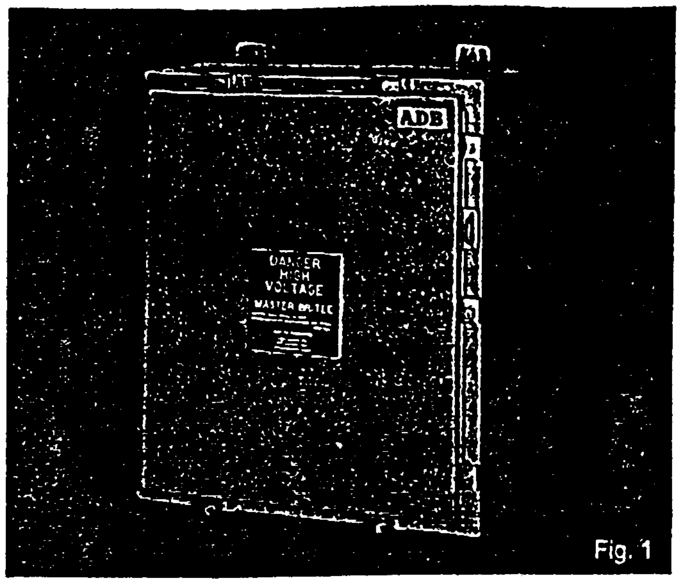


Fig. 1

USES

Today there is a growing need for a ground movement guidance and control system to prevent incursions onto an active runway and collisions between aircraft, especially during conditions of low visibility.
The ADB BRITE System, an addressable electronic module, is an essential component in surface movement and guidance control systems (SMGCS).
It provides a basis for selective control and monitoring of a single light or group of lights plus a variety of aircraft sensors. The location of individual lamp failures can also be monitored.
Since there is no requirement to install separate communication cables, the Bidirectional Series Transceiver system (BRITE) provides true bi-directional communication on new and existing airfield lighting series circuits.

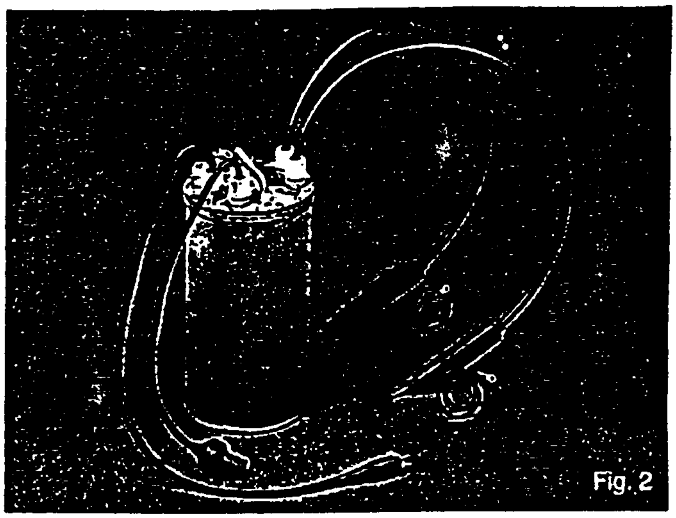


Fig. 2

SALIENT FEATURES

- **True bi-directional communication on series circuit is provided without requiring separate cables.**
- **May be retrofitted into any existing series circuit system.**
- **High communications rate between the Master and any Remote BRITE (4800 Baud).**
- **High degree of communications reliability through the use of CRC16 (Cyclic Redundancy Check) error checking on communications signal between Master and Remote BRITE.**
- **Extremely rugged surge protection provided on all external wiring connections of Master and Remote units.**
- **One Master can communicate with up to 255 Remotes.**
- **Remote BRITE designed to meet the 15000 V DC primary dielectric strength requirement given in the FAA L-830/L-831 isolation transformer specification.**
- **Strong, waterproof (NEMA 6P rated) construction allows the Remote BRITE to be placed at any L-867/L-868 base location on the airfield.**
- **Test port is available to test Remote BRITE in the field.**
- **Re-enterable construction of Remote BRITE allows reduced maintenance costs in comparison with resin-filled units.**
- **50 Hz or 60 Hz operation.**

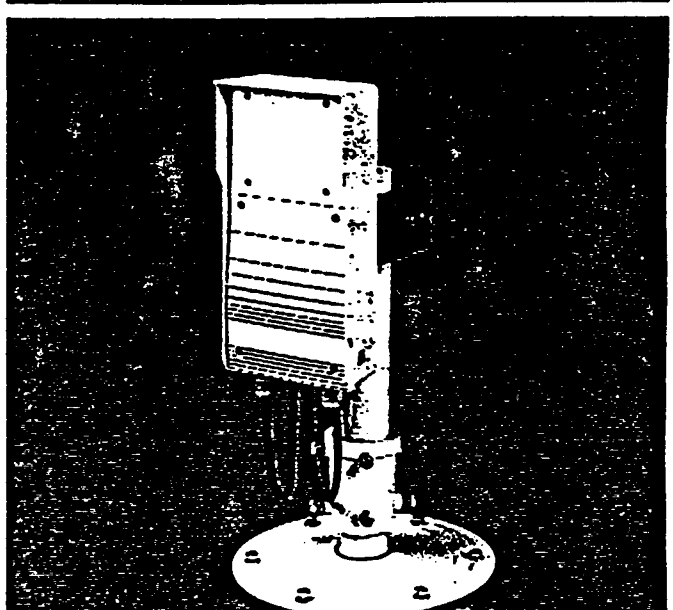


Fig. 3

SYSTEM DESCRIPTION

A typical BRITE system may have the following components (Fig. 4):
- Master BRITE (Fig. 1)
- Remote BRITE(s) (Fig. 2)
- Presence sensors/detectors (Fig. 3)
- Bypass Unit(s) (Fig. 7)

*Patents pending.

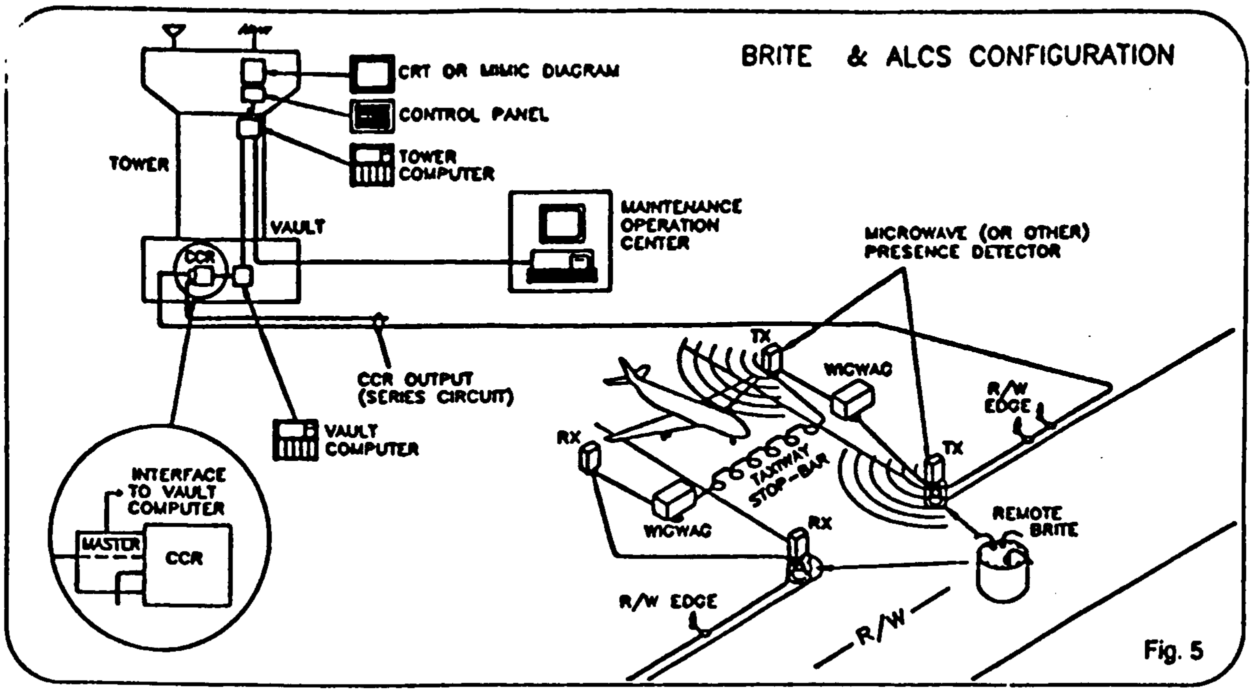


Fig. 5

Normally the BRITE system is used in conjunction with an Airport Lighting Computer System (ALCS), also shown on fig. 5, with the following components:

Tower Control Panel

Serves as the primary operator interface with the BRITE system. It can be a conventional FAA L-821 control panel, a pushbutton panel or a touch-sensitive screen.
The conventional mimic diagram using lamps or LED's as indicators or optical fiber may be replaced by a CRT monitor.

Tower Computer

- Translates operator inputs into airfield lighting commands. It continuously scans the control panel settings and decides which lights should be controlled and to what circuit they belong.
  It then transmits the commands to the AFL Substation Controller (Vault Computer).
- The Tower Computer also collects fault and other data from the AFL Substation and, after processing, sends a status report to the Tower Control Panel and to the Maintenance Center Computer if provided.

AFL Substation Controller (Vault Computer)

- Its main task is to transmit the commands received from the Tower Computer to the Master BRITE and to the CCR's.
  It will also transfer to the Tower Computer the back indication signals received from the Remote BRITE's via the Master BRITE.
- In case of communication failure between the Tower and AFL Substation Computers (Vault Computers), the latter will set all CCR's to a pre-defined "fail-safe" setting. Each Remote BRITE will also revert to a pre-defined "fail-safe" setting.

Presence Sensors and Detectors

Various types of presence sensors:
- Microwave
- Piezoelectric
- Inductive loop
  etc...

may be controlled and monitored by a Remote BRITE.
Automatic control and monitoring of taxiway stop bars and taxiway centerline lights is thus possible and can be incorporated into the ALCS. The system can then be incorporated as a subsystem into a Surface Movement and Guidance Control System (SMGCS).

Optionally

A computer and a CRT monitor are installed at the Maintenance Center.
The main purpose of the Maintenance Center Computer is to collect information for statistics and maintenance planning.

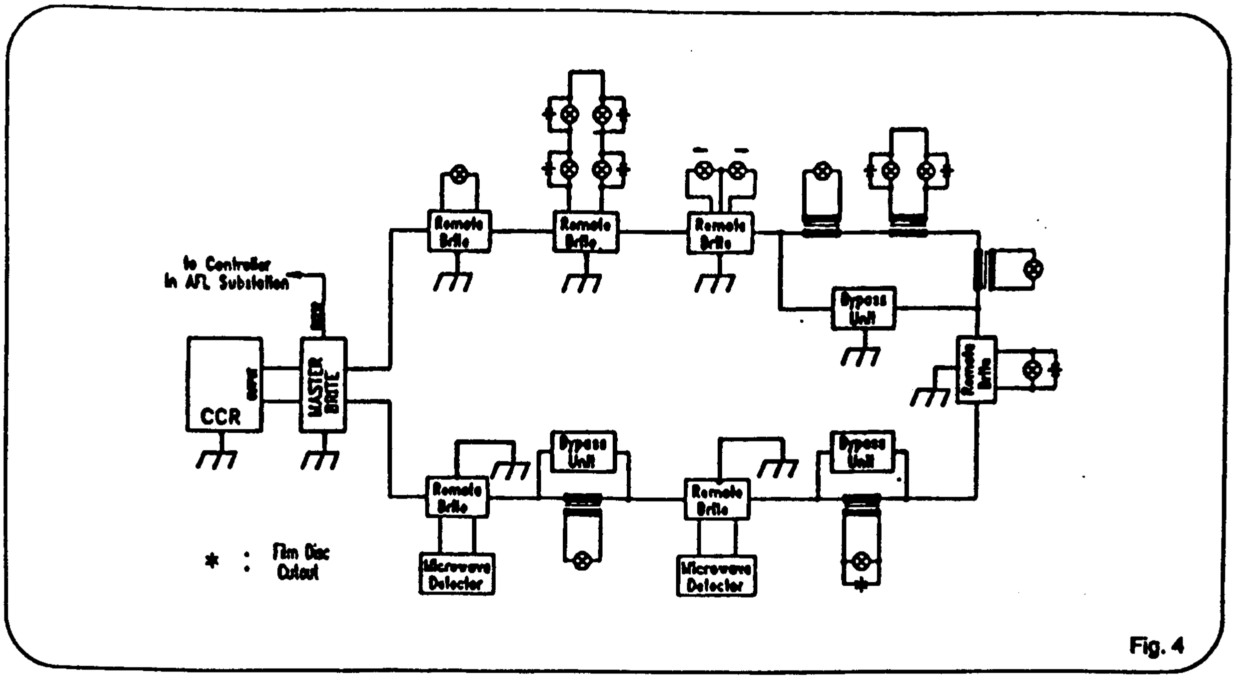


Fig. 4

DESCRIPTION OF COMPONENTS

Master BRITE

- It receives command signals from the AFL Substation Controller (Vault Computer) and transmits them on the series circuit to the Remote BRITE's.
- It also converts monitoring signals received from the Remote BRITE's and transmits them to the AFL Substation Controller (Vault Computer).
  In this bi-directional communication function, one Master can communicate with up to 255 Remote BRITE's connected on the same series circuit.
- One Master is needed for each series circuit with Remote BRITE's. It is installed/connected on the output of the corresponding CCR.
- The Master communicates with the AFL Substation Controller (Vault Computer) via RS-232 cable (or optionally EIA-485 cable). Numerous Masters can be connected to a Vault Computer.

Remote BRITE

- It is a microprocessor-based unit with a dedicated address. It will react only to an address-coded, pulsed signal from the AFL Substation Controller (Vault Computer) via the Master.
- It is installed in the field close to the light or to the device to be controlled/monitored.
- It controls the load connected to its output, which can include switching on or off a lamp or a group of lamps, or setting the lamp load to a certain intensity.
- It monitors and reports the required parameters of the load connected to its output. Monitoring of lamp status is continuous.
- One version of the Remote BRITE incorporates a lamp isolating transformer and a bypass device. In another version the isolation transformer is external to the Remote BRITE. This allows existing L-830 transformers to be used and reduces the cost of the system. The Remote BRITE is a fully self-contained unit that connects to the series circuit by means of L-823 single-pole connectors and to the light fixture by means of a L-823 two-pole socket.
- Power to operate the Remote BRITE is derived in series with the lamp. Therefore, lamp current is not reduced due to power consumption by the Remote BRITE's internal power supply.
- The metal enclosure of the Remote BRITE provides for increased heat dissipation. Internal components operate at a lower temperature, thereby increasing reliability.
- The modular expandable design of the Remote BRITE enhances flexibility and facilitates future expansion of functions.

Bypass Unit

- It is connected across the primary of individual or groups of isolating transformers. (Fig. 7).
- Its function is to provide a low-impedance path for the communication signal.
- Surge protection is built into the unit.
- Connection to the isolating transformer and to the series circuit is by means of L-823 single-pole connectors. The unit is waterproof and can be installed in L-867/L-868 bases and transformer pits.
- Three models are currently available (Fig. 4):
  - To bypass the primary of a single L-830/L-831 isolating transformer when the lighting fixture is provided with a film disc cutout connected across the lamp terminals.
  - As above, but when no cutout is provided.
  - To bypass a group of isolating transformers.

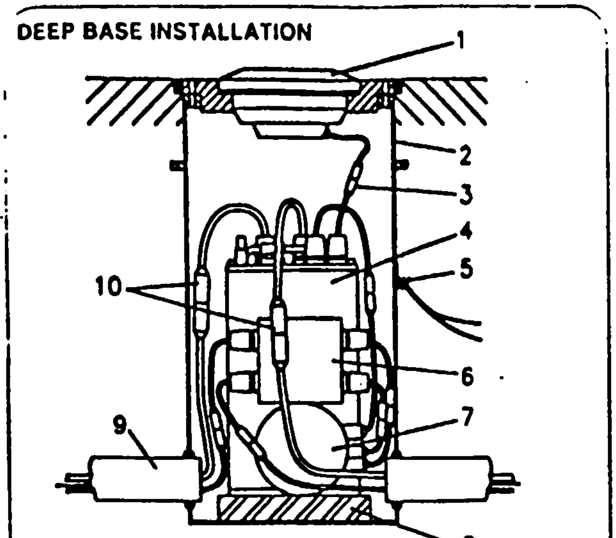


Fig. 6

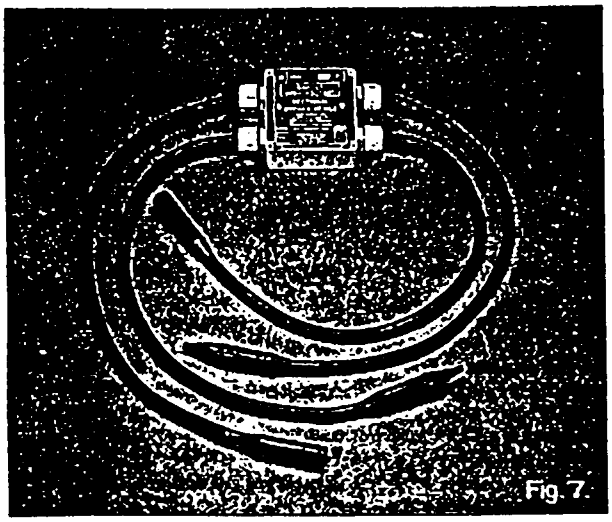


Fig. 7

INSTALLATION (Fig. 6)

1. Stop bar light
2. FAA L-868 base
3. Secondary connector
4. Remote BRITE
5. Earth terminal
6. Bypass device (Fig. 7)
7. Isolating transformer
8. Spacer
9. Conduit
10. Primary connectors

TECHNICAL FEATURES

MASTER

- True bi-directional communication on series circuit is provided without requiring separate cables.
- Polling time between the Master and any Remote is 4800 Baud.
- The Master can communicate with up to 255 Remote units.
- High accuracy in communications thanks to the CRC 16 (Cyclic Redundancy Check) error checking on communications signal between Master and Remote.
- Anti-Babbling Timer prevents a transmitter from being stuck on and tying up the communications network.
- Watchdog Timers provide fail-safe operation in all Remote units.
- Extremely rugged surge protection is provided on all remote external wiring connections.
- RS-232 or EIA-485 connection.
- 60 Hz or 50 Hz operation.

REMOTE

- Modular, expandable Remote BRITE unit design enhances flexibility and facilitates future expansion.
- Receive commands and monitoring requests from the Vault Computer via the Master with a high degree of communications reliability and resistance to electrical surges.
- Controls the load connected to its output, which can include switching a lamp or lamp block on or off.
- Monitors and reports the status of the load connected to its output. Monitoring of lamps is continuous.
- Performs self testing and automatically reports its operational status and that of the series circuit.
- Any combination of four inputs or outputs (high or low) are available on the Remote BRITE as a standard. Two additional inputs can be analog (for current or voltage sensing) . An optional I/O extender PCB can be added to extend this capability.

SUGGESTED SPECIFICATION

The system will be able to control and monitor individual lamps or group of lamps fed through existing or newly installed series circuits. The system will consist of a master station to be installed in the AFL-substation and remote units placed into L-867 / L-868 bases. The system will use the series circuit for bi-directional data communication between master and remote. The communication rate will be at least 4800 Baud shall have CRC 16 error checking and will be provided with surge protection. The master will be able to communicate with at least 255 remote units and will have a serial port RS-232 for a data link with the airport control system. The remote will incorporate an anti-babbling timer and watchdog timer providing a fail-safe mode. The master shall have a lightning protection rating equal to that on the output of the CCR. The remote units shall be of a modular, rugged and waterproof construction. The remote unit shall be addressable without opening the unit and shall be provided with a test port to allow local trouble-shooting. Connection of the remote into the series circuit shall be by means of FAA L-823 connectors. The remote unit shall be designed to meet the 15000 V DC dielectric strength requirements per FAA L-830 / L-831 specification. Finally, the system shall be able to receive the signal of an aircraft or vehicle detection system. The remote unit connected with the presence sensor system shall use the series circuit to send any information through the master to the control system.

ORDERING DATA

Please contact ADB.

ADB
A Siemens Company
977 Gahanna Parkway
Columbus, Ohio 43230
614-861-1304
Fax 614-864-2069

APPENDIX C

SUMMARY OF USER-PILOT QUESTIONNAIRE COMMENTS

SUMMARY OF USER-PILOT QUESTIONNAIRE COMMENTS

Air-carrier pilot comments, as entered on the user-pilot evaluation questionnaire forms, are provided below. The excerpts, while not necessarily direct quotes of individual pilots, reflect the general nature of the comments.

1. It was hard to tell if the system's colors and intensities were appropriate for low visibilities because we were evaluating the lights with 15 miles of visibility. I assume they would. (3 pilots)

2. We really liked this system...Thought it was quite "spiffy"!

3. After acclimatizaion, it would be difficult to misunderstand this system.

4. The system display is quite clear in meaning. (2 pilots)

5. Seems to be a good system.

6. It is kind of hard to tell how the system would perform with such a short exposure.

7. The system is easy to see. It is much better to cross the path (with lights) than (to have) a sign on the side.

8. The system's location makes it unlike any other system. This will prevent any confusion.

9. Being based at SEA I have received great exposure to the system.

10. The high intensity of the taxi lights are distracting and prevent good vision at night under VFR conditions. (Ramp obstructions, gates, vehicles hard to see)

11. Excellent. All airports need this.

12. The system will do okay in preventing inadvertent runway incursions, but not much more than the runway markings.

13. I never saw red lights, they looked sort of orange/yellow. The second approach I figured out which lights you meant.

14. All the lights are blindingly bright. I was there when the RVR was 12/14/14.

15. During my early morning departure (0840), the intensity of the lights could be brighter. The red was easy to see but the green was not.

16. The red stop bar really stands out.

17. I looked at all intensities and they looked good.

18. System worked well.

19. System looks very good. Coloration is good. Brightness good. (2 pilots)

20. The system would do an excellent job in preventing runway incursions.

21. There is no way a pilot would cross the red stop bars. (3 pilots)

22. VFR night- I tried 10, 30 and 100 (%) intensity...looks good.

23. System is very effective.

24. I would like to see this system the entire length of the runway. Crossing the active runway is still a hazard.

25. The reds are good and red - very distinctive. (2 pilots)

26. The light intensity was varied to demonstrate the ability. Adjust the lights to the weather and light conditions...It appeared to be satisfactory.

27. The system is very effective, especially the taxi lights leading to the center line.

APPENDIX D

SUMMARY OF AIR TRAFFIC CONTROLLER QUESTIONNAIRE COMMENTS

SUMMARY OF AIR TRAFFIC CONTROLLER QUESTIONNAIRE COMMENTS

Air traffic controller comments, as entered on the controller evaluation questionnaire forms, are provided below. The excerpts, while not necessarily direct quotes of individual controllers, reflect the general nature of the comments.

Question 1

1. Control panel mounted in the wrong place. Panel should be front mounted and a box below runway lighting panel with taxiway lighting.

2. Some of my co-workers have a hard time operating the control panel.

3. We have received numerous instructions on what setting both runway and taxiway lights need to be on for the lights to work. What is the correct answer?

4. In my limited experience, the panel is fine. A volume control for the alarm would be nice.

5. Once you clear aircraft for takeoff, you don't have a lot of time until red lights turn back on. Local control will have to make sure aircraft is presently holding short at the hold bars before depressing panel.

6. Control panel has not been used enough to determine reliability. Insufficient use. (4 controllers)

7. No instructions close by in case you have forgotten the order of buttons to push.

8. It does not seem to stay on line very long before problems occur and they are not always the same problem.

9. Up to now, the system was never up long enough to be usable. The location of the control panel not user friendly.

10. User friendly for the pilots maybe, it takes too much time to analyze the panel and make the right corrections.

Question 1a

11. Beacon-on light is tough to see when in a RWY 34 flow.

12. Because of where we have it installed, the panel itself could be better designed and more compact.

13. No variations in lighting conditions were encountered...Light too constant - no control.

Question 1b

14. Because of where it is installed at this facility, the dimmer is easily broken and damage to other components is likely. The dimmer switch could be moved thus reducing the chance of breakage.

15. Used so seldom that panel could be anywhere.

16. Problem with where the control panel was placed in the tower. Get it out of the work area. We rarely use it and the panel does not need to be so close.

Question 1c

17. Not enough use to experience any problems. (2 controllers)

18. Problem: You push the button, it does not wait for the cancel button to finish its cycle.

19. Problem: Buttons sometimes come off. Inadvertent activation is not likely, but it could be better designed. These designs need more controller input.

20. Problem: Depending on how you depress the keys, the tops (of the keys) will fly off. This situation has happened more than once.

21. When the stop bar lights are activated, all the necessary settings should come on with the touch of one button.

Question 2

22. During this period, there was low activity with aircraft traffic.

23. It is very distracting while looking for the button and trying to insure timing when controller should be focusing on BRITE and Runway.

24. Unknown. Have not used stop bar system that much.

25. When the system is needed, it should only take 60 seconds or less to activate.

26. After we get used to the operation, the extra workload should be minimal. (2 controllers)

27. Every time another procedure is added (or required) for the local controller, it increases the workload of the local controller.

28. It is yet another distraction or duty for a typically busy position.

29. Not so much in use (we are rarely below 600' RVR) but all the installation and problems have been distracting.

30. On 10/29/92 the stop bars didn't work right - it kept alarming and OPS had a hard time completing the Category III check because of it - talk about a distraction! Weather had come down rapidly and the stop bars caused a lot of headaches.

31. Any other function that the local controller had to do distracts from the working situation. Another item to distract the controller.

32. At this time during conditions which require its use, no, it is not a problem. But as more planes operate at low visibility, it will be more of a hassle.

33. At first it did cause an increase in workload. Once it was running smoothly, it was easy.

Question 3

34. Not sure if the stop bars reduce runway incursions, not enough experience.

35. Stop bars are for departure RWY 16 R - Until RVR goes below 600' we depart RWY 16 L.

36. I think with the use of centerline taxi lights, wig wags, and hold-line lights we could do without the stop bars. However, the black hole concept is a good idea, but I'm not sure if it will reduce incursions.

37. It might possibly reduce incursions, but it has had no impact so far.

38. A good ASDE setup would do a better job.

39. Runway incursions will increase due to controllers attention being on the operation of the equipment rather than the traffic.

40. It should reduce the chance of a runway incursion, however, it will slow things down.

41. It may help eliminate incursions at the approach end, but the lighted hold line at the runway exit has already caused problems.

42. It will help reduce incursions if it is used with the hold-line lights and wig-wag lights.

43. It surely can't hurt in preventing incursions unless the equipment does not work or is not user friendly.

44. During low visibility and aid to help the pilots and controllers will make our operations safer.

45. I think the hold bars and spots will also help in reducing incursions.

46. Yes it will reduce incursions, provided that all intersections have hold bars or stop bars available. The new signs are a great aid, so at least pilots know where they are.

Question 4

47. Traffic is slow in low-visibility conditions anyway, so the stop bar implementation had no impact.

48. Minor delays occurred during daytime testing/ troubleshooting.

49. No delays have occurred, because we haven't really used it yet. (5 controllers)

50. Sometimes the light takes longer to cycle through so aircraft stop until the light catches up.

Question 5

51. Cannot tell if the alarm provisions worked from the tower panel.

52. Irritating sound - should be adjustable volume so you don't have to hear it until using the stop bar.

53. Too many bells and buzzers. It can now alarm and no one knows what unit is haywire.

54. Some people feel there are too many bells and buzzers. But they do work!

55. Not enough use to determine if the alarm provisions worked. (3 controllers)

56. I have received numerous false alarms (usually on mid-shifts).

57. Have had many false alarms.

58. I don't believe any equipment has the capability to provide satisfactory indications without false alarms. It is good enough.

59. Due to the many bells of the same tone that go off in the tower, it only makes you aware, but does not identify which equipment is sounding.

Question 6

60. The clearance cancellation feature should be a kill switch. It should be on another pushbutton. (3 controllers)

61. Haven't had to use it yet. (3 controllers)

62. When seldom used, many will not remember this feature. (2 controllers)

Question 7

63. Change time duration for clearance cancellation to 30 seconds.

64. Have you ever noticed how slow some aircraft taxi?

65. It takes an aircraft 1:54 min. to reach the airport from the outer marker, in same cases, if he hasn't moved in 30 sec - too late!

66. I feel 60 seconds is a good balance since anything less would no doubt be a problem, and more would defeat its purpose.

67. Increase time to 90 seconds until cancellation.

68. No it isn't enough. It doesn't give you 60 seconds anyway. It changed back in 20 seconds last time I used 34L. (2 controllers)

69. Change time until cancellation to 120 seconds.

70. Automatic features go at this time, with not too much use. In the future, the time feature may have to be adjusted.

Question 8

71. Pilots complained that wig-wag lights were too bright.

72. Pilots get confused in several ways. 1. Maintenance would play with them in VFR Wx and pilots would stop right in the middle of crossing the runway and ask what was going on. 2. When RVR is more than 600', but less than about 2400', the pilots want to know where the stop bars are when departing RWY 16L.

73. All pilots I have talked with like the system as far as centerline pink spots, and wig-wags. No criteria on stop bars, but not sure if they are needed.

74. Not enough pilots have observed these lights to make evaluation. With time, but for now, they are just too new.

75. Hold bars cause some confusion.

76. They are too new. Pilots will have to be briefed on them by companies. Have not been in service long enough to give any long term comments.